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C.W. Ammen

METALCASTING

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INTRODUCTION

For the nawly fledged novice metal caster, the person working for bis or ber own amusement, a bobby foundry is easy to start, lots of fun, and easy to advance from to larger or more intricate set-ups sbould those becoma desirable.

Any sucb foundry can be fully or partially self-sufficient, allowing the metal caster to work either for the fun of it, or for a large enougb profit to pay axpenses (and maybe a bit more). Items cast for sale become products, and the procass acquires a further complexity because of that (tax tima, folks). But for thosa around you, you suddenly become the person to see wben a small part for a tool, or other davice, cannot be found. Quantities too small to interest the average job shop, as well as jobs that are overly complex or involved, or that require lots of labor in relation to return in other ways, can be your meat, wbile the job sbop eats up tha big stuff. . .leaving the entire small item field bobby and small job metal caster wbo operates out of bis or ber backyard (essentially: that's more of a figure of speech than a reality for some people wbo are overpowered by zoning laws, if not by neighborly disapproval of noise and odor).

Tbe metal casting industry bas followed a familiar pattern in this country, moving from wbat was basically a cottage craft, with craftsmen working to turn out from one to bowever many items ware needed, on to a largar industry wbere the small job needs of many are lost in the shuffle. Limits bave been added to the alloys with whicb a particular foundry might work, as well as limits baing stuck on weights of castings, types of castings and so on.

As specialization increased, cost-control became a major factor, and *captive shops*, tightly controlled within the parent industry, came into being. As recently as thirty yaars ago, there were thousands of foundrias of small to medium size in the country: today, a fraction of that number remains, and many of the independent middling large foundries ara in trouble.

Tbe jobbing foundry is predicted to be almost extinct in the not-so-distant future: that cbange is an opportunity for those among you who wish to carry on a bobby that pays for itself. . .or maybe mora than pays for itself.

The demand for one-shot metalcasting job work will exists, as does lots of other low production work wbere a few units of varied sizes may ba needed, and may always do so, but the work often goes begging for lack of anyone to do it. And, of course, there's always the jewelry casting market, if one wishes to go beyond casting for ona's own pleasure and use. If your own business has a nced for cast parts, then, of coursa, you're going to have a running start with a small foundry of your own, functioning something like the captive foundries of big businass, but on a smaller, more personal, and lower production scale.

If, for wbatever reason, you wish to cast parts for sale, whether as art or practical accessories for living, low volume sand casting is tbe way to go. Casting metal parts can be one of the most creative and rewarding activities for tha bome craftsman, or woman, to undertaka. Not as many amateurs try thc work as migbt enjoy it. The assumptions made are often wrong: equipment levels need not be high (thougb like all otber equipment intensive hobbies, this one is apt to craate a desire for more gear as time goes on); skill and know-bow can be picked up in the same manner as many people pick up woodworking skills (thougb there ara few adult education courses in metalcasting, reading books and talking to other metal casters and starting small and working up do wonderfully well). Thera is seldom a valid reason that tbe home shop can't bacome a site for metal casting activity.

Advice is easy: don't expect to learn it all in a week; don't expect to be a successful professional without mora than a small amount of work, aven on a very reduced scale; don't rusb. There's not really a need to have an ultimate, or immediate, goal in mind at the outset. If the work looks as if you'll enjoy it, give it at try.

A word to the wise, though: if you spend lots of time worrying about the condition of your nails, how your hair is combed, and tha details of your clothing, you're probably not going to like metalcasting. Tbe work is often physically demanding and dirty, thougb anyone with average strength and manual dexterity should be able to easily handle foundry work.

CHAPTER

1

Casting Processes

There are e number of basic casting processes that are availeble to the smell-job metalcester. Some of these processes are among the earliest ettempts by mankind to form and manipulete metals.

Sand Casting

Of the total tonnege of castings produced eacb year, the greetest percentage is produced by sand casting. Crude methods of sand cesting were precticed before the beginning of recorded bistory.

Tbe ancient Chinese produced e large quantity of extremely fine and compliceted bronzes, some of which were quite massive. Careful, unbiesed studies of these bronzes through X-rey examinetion end chemicel anelysis of the core meterials bas been most enlightening. Some consist of many sand cestings essembled with cleverly designed hidden joints (undetecteble except by X-rey examination). Tbe surfece texture, in the mejority of cases, is not an es-cest finish, but e carefully chased and hand-engraved one. Tbe mold material consisted of fine

QUICK>>>TIP **Sand casting may be crude or refined. It consists of pouring molten metal into a formed mold to produce a solidified object of that metal.**

QUICK>>>TIP **Flasks are containers, or frames, for molds. There usually is a bottom flask and a *cope* or top flask. There may be *cheeks,* center or intermediate sections that fit between the bottom flask and the cope. The cope may be weighted or clamped to prevent it from lifting during the pour.**

silica and natural cement (e sand loam) and in some cases, e neturel bonded green sand very similar to French sand. Not only were the Chinese clever at making joints, they made some highly compliceted piece molds.

(When examining a bronze, you are not looking et the item as cast but, rather, the finished chased and petined work: it might have been produced by any number of methods. The T. F. McGann & Sons Co. of Boston produced countless fine statuary bronzes in French molding sand by the green sand molding process.)

New York is the home of over 300 examples of buildings mede from iron members cast in sand; some, highly ornamented, were produced before structural steel was widely used. The French Quarter of New Orleans hes fine examples of balconies and fences commonly thought to be wrought iron; they are for the most part not wrought iron et all, but grey iron cest in sand. Some were produced in France from finely carved wooden petterns.

Sand cesting consists of pouring a molten metal or alloy into a mold of earth or sand and allowing it to solidify. Molding material is cheap and plentiful. It is also reedily worked into suitable molds, making sand casting the most economical method. Machining or building up e part by welding, riveting, or brazing is surely more expensive than cesting. Sand casting is also an extremely versetile process. Parts can be made in elmost any size varying from a fraction of an ounce up to tons in weight.

Green Sand Casting

Green sand refers to molds mede and poured with sand simply tempered with water.

Green sand molds are sometimes made in two-part flasks. The pattern is placed on e smooth molding board and covered with an in-

verted drag flask; green sand is rammed down firmly into drag flask, leveled off with the bottom, and covered with a bottom board. The boards and flask are then overturned and the molding board removed.

This leaves the upper face of the pattern at the flask parting plane. The cope is placed in register on the drag and the sand face of the drag flask is given a light coating of parting powder (a commercial product) to keep the two halves of the mold from sticking together.

A sprue stick is placed in position with the cope and surrounded with sand tamped firmly to the top of the cope flask. After the sand is leveled off, the sprue stick is removed. Tbe cope flask is lifted off and set aside; the pattern is removed from the drag flask and a gate is cut over to the sprue for the entrance of metal to the mold cavity. The entire mold is blown clean of any loose sand and the cope is replaced. Tbe mold is then ready to pour. Weigbts are placed on the cope to prevent it from lifting when poured (and causing a *run out*).

After pouring, the metal is allowed to solidify, the mold is shaken out, and the casting and gate are removed.

Due to the lack of grain coherence, pure sand is not suitable for making molds. A binder is needed to hold the sand particles together. Clay is perfectly suited for this purpose. However, an abundance of clay is undesirable because the sand then loses its porosity, and porosity is essential for the escape of gases when the molten metal is poured into the mold.

SAND CASTING (CHEMICAL BINDER)

Chemically bonded or *furan molds* are produced by mixing a chemical binder with clean dry silica sand and adding a catalyst to barden the binder.

Chemically bonded molds are a very good medium for large bronzes and can be used with oil-and-clay patterns, as well as for wood. Tbe molds have little strength in the green state and cannot be used like green sand. You must make up the drag balf of the mold, allow it to set, and then remove the cope and finisb the mold as usual. It has no equal for piece molds and highly complicated molds, once you get the hang of it.

Its high strength when cured allows relatively thin molds for beavy section castings.

QUICK»TIP

A *sprue* is a feeder hole through which molten metal is poured.

Because no moisture is involved, the yield of good castings is extremely high. The basic formula is:

Binder—2 percent of the weight of sand
Catalyst—25 percent of the weight of the hinder

Tbe binder is furfural alcohol; the catalyst, an 75 percent phosphoric acid solution.

First mix the sand with the acid, then add the binder and mix thoroughly. You have 20 or 30 minutes to work hefora the sand sets. The catalyst reacts with the binder to produce a hard resin, which cements tha grains of sand together to form a hard, yet permeabla mold. Any metal can ba cast in furan molds.

Unlike green sand molds, where the sand can be retempered and used over again to produca naw molds.

SAND CASTING (OIL BINDERS)

Molds and cores can he made hy mixing silica sand with linseed oil or any number of commercial drying oils. Bacause this is tha usual mathod for producing cores, a mold made with a *drying* oil binder, such as linsaed oil and silica sand, is called a *core mold*. Due to its low green strength, it requires special pattern equipment and rigging; it has been largely replaced with furan methods. To maka sucb a mold mix 40 parts (by voluma) of clean silica sand with ona part (by voluma) of linsaed oil. Dry the mold complataly at 350 F. The oil oxidizas during drying, binding tha sand grains togethar. Lika furan molds, it is a ona-time material. Unlike furan, oil binders require baking to sat a bond.

TOOLS ***Binders*** **hold the sand in shape once the pattern is removed and until the pour is finished. There are a number of binders available, some simple (mostly clays) and others more sophisticated (some clays, chemical and oil binders, silicate of soda gassed with CO_2).**

SAND CASTING (CARBON DIOXIDE OR SILICATE OF SODA)

The CO_2 system, or *silicate of soda method* is, like the furan system, very widely used.

When CO_2 contacts tha water in silicate of soda, carhonic acid is formed. The acid neutralizes the silicate of soda, forming a glass bond for the molding sand.

Cores and molds may require es little es 2½ percent silicete of soda binder, to as much as 4 percent, depending upon the mass involved. Various gredes and formulations of silicete of soda are availeble for e wide range of applicetions. The advantage over furan binders is the short time it takes to "gas" a mold or core—in some ceses, 10 seconds or less.

After the sand and silicate of soda are gassed, the mold is reedy to pour. This makes for very rapid production. It is not as versatile as the furan method, in that manifolds, probes, a tank of CO_2, e regulator, hoses, and gassing cups are required.

Sand Casting With Styrofoam Molds

In this method, the object to be cast or reproduced in metel is first mede es e Styrofoam pattern. The Styrofoam pattern is surrounded with green sand in a flask. When molten metal enters the mold, the heat vaporizes the Styrofoam.

This system is ideally suited to large and chunky castings due to its simplicity. However, its voluminous output of noxious smoke hes caused considereble grumbling from the EPA; and, it is outlawed in some areas. Done on a smell scele, and infrequently, it might be toleroted. You need e new pattern for each cesting.

Die Casting

Die cesting is e very rapid method of producing large quantities of costings. As the name implies, the mold cevity is e *die*—a permanent metal mold into which casting metal is introduced under pressure.

The process is suitable only to relatively bigb production jobs, where a large quantity of e given cesting is desired. The initiel cost to make the die and the high cost of die-casting machines make it imperative that sufficient quantities of a given casting are needed to justify the high cost.

Basically, there are two distinct types of die-casting equipment: the *hot chomber* and the *cold chamber*. In the hot chamber (Figure 1.1), the mechanism that shoots the metal into the die to produce eecb cest is submerged under the molten metel in the machine's melting pot. This makes it automatic in the sense that the "shot" cylinder is euto-

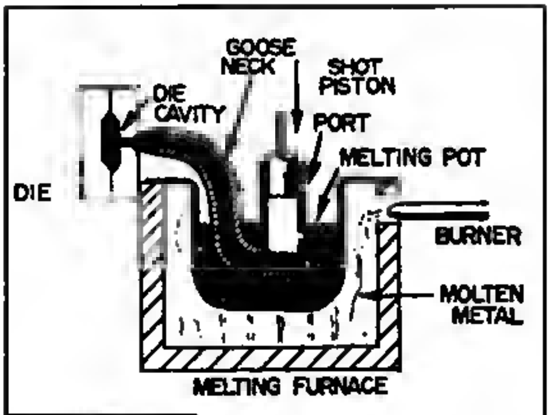

FIGURE 1.1

Hot chamber die casting.

maticelly filled with metal for each shot, making it unnecessary for the operator to ladle metel into the cylinder for eech cesting or shot.

The cold chamber machine (Figure 1.2) requires that the shot cylinder be filled manuelly by the operator for each casting (or shot). The required amount of metal is poured into the shot cylinder and the shot piston is edvanced, shooting the metal into the die cavity.

Plaster Mold Casting

Plester mold cesting hes e number of epplicetions. The method is e varietion of send cesting. Insteed of using sand to meke the mold e mixture of plaster, talc, and water flow up around the pattern. After the plastar has set, tha pattern is withdrawn. Tha mold is than baked in an oven, driving off moistura. This process is more expensive than sand cesting, but it does offar e highar degraa of dimensional accuracy.

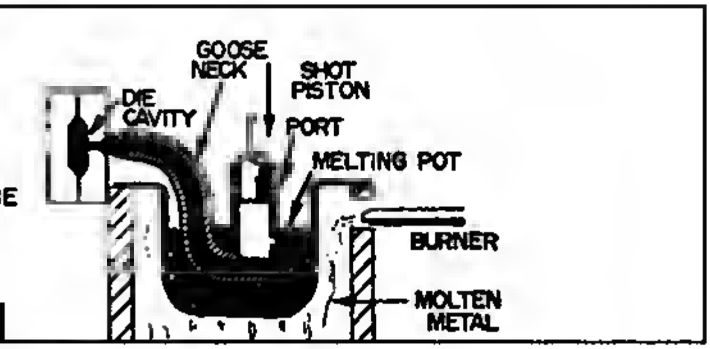

FIGURE 1.2

Cold chamber die casting.

Shell Mold Casting

Shell molding is sometimes called the *Croning Process* after the invantor. It uses a mixture of sand and tharmosatting resin. This mixture is usually phenol-formaldehyde and it forms tha mold. This sand-resin mixture is brought into contact with a beated pattern. The mixture closest to the pattern forms a thin shell dua to tha polymerization of the resin, which binds the sand particles. The thin shell is then usad as a mold, backed up by loosa sand or shot to give it strength. Excellant finish and dimensional accuracy are thus obtained. Shall molding is a large-scale industrial process because of the required expensive production machinary.

Slush Casting

In slush casting, a metal mold in two or more parts is used. The mold is fillad with matal and rockad back and forth until tha matal (touching tha mold surfaces) solidifias in tha dasired thicknass. When this point is reached, the liquid metal remaining in the mold is poured out, resulting in a hollow casting. This systam is usad only for low-malting laad and zinc-based matals, and to produce ornamantal itams that naed not be strong.

This systam is similar to tha procass usad to slip-cast clay pottary. The slip in this casa is metal, and, the mold is made of metal (usually bronze) rather than plaster of paris.

QUICK»TIP

Industrial processes are those that are too costly in terms of materials or tools for the small shop. These include *die casting*—the use of permanent metal molds, or dies, and pressurized injection of metal (the need for very large quantities, however, may reduce the cost per unit to a profit-making level for even small shops); and *shell mold casting*—the use of sand and a thermoset resin to bind the sand—which is cost-prohibitive for small foundries.

Permanent Molds

Permanent molds are metal molds designed to be opened and closed. Tha metal is pourad into the mold, and when solidified, the mold is opanad and tha casting is removed; the cycle is then repeated.

Two very common types of permanent molds, which have been around for many years, are those used to make bullets and sinkers for fishing. Howaver, permanant molds are not limited to these types of castings. Hundreds of thousands of different kinds of permanent mold castings in many sizes are mede each year. Over 90 percent of all automotiva aluminum pistons and most cest aluminum cookware are produced in permanent cest-iron molds.

There are other casting methods; but by and large, the methods described eccount for the largest portion of tha cestings produced today.

Casting Defects

A knowledge of cesting defects is essential. If you cannot pinpoint the causa of a dafect there is no way of correcting tha problem. Some dafacts are quite obvious, elong with the ceuse. Some types of defects can often rasemble each other in eppearance and sapareting them is difficult. A drewing or photograph of e defect is one thing and looking at tha actual defect is another. You learn ebout defects by anelyzing your own and those of others.

Here is e list of defects and their causes, which should include anything you might even encounter:

- **Blacking or Mold Wash Scab.** Occasionally the blecking or wash on the mold or core breaks ewey during heeting, lifts off the surface like e leaf, and is reteined in or on the metel. This is e form of sceb. The ceuse is e poor binder in the wesh, improperly dried wash, e poor wash formule, or ell of the ebove.
- **Bleeder.** A bleeder is caused by shaking the casting out of tha mold too soon, while e part of the casting is still liquid. The section runs out, leaving e defect. In extreme cases, the entire center section may run out—onto the shake-out man's feet.
- **Blister.** A blister is a shallow blow (*see below*) covered with a thin film metal. It has many of the same causes and cures as blows.
- **Blows.** Blows are round to elongated holes caused by the accumulation of trapped gases. The usual cause of blow holes is sand

that is rammed too bard, wbich decreeses its permeability. Other ceuses are sand permeability too low for the job; sand and core too wet; insufficient or closad-off core vant; green core not properly dried; an incompletely dried core or mold wesh; insufficient mold vanting, insufficient bydrostatic pressure (cope too short); cope hars too close to the mold cevity; wet gegger or solder too close to the mold cevity; or poor grain distribution. Any combination of bot or cold materials thet could leed to condensation es the bot core sets in e cold mold, or vice versa, can ceuse blows, as can a cold chill, or wet or rusty cbaplets.

- **Bobble.** The cesting was poured sbort, usually with a slacked or interrupted pour. When pouring e casting, the metal must be poured et a constant valocity to bold choke. Slacking off or reducing velocity causes bobble. A completely interrupted pour, with e start and stop and another start even for e second or so can create bobble. Many lost castings are causad hy improper pours.

- **Broken Casting.** May be ceused by improper casting design. Improper filleting, along with impropar handling anywbere elong the line mey break the casting. Copper hese castings—rad hrass, yellow brass, and so on—are known es *hot short*, whicb means they break easily when hot. Tberefore, e casting sbaken out of tha mold hefore it has cooled enough mey be very eesily broken. A mold or core with too high a hot strength doesn't give or collapsa enough to give the casting room to move as it shrinks; this elso mey be a causa of hroken castings.

- **Cold Shut.** A cold shut occurs wben two streams of metal coming together in e mold fail to weld. Cold shuts are usually caused by e too-cold metel poured too slowly, or an improperly designed gating system, where the mold cannot be filled fast enough.

- **Core Rise.** Core rise creates e variation in wall thickness, or a complate lack of metal at the point where the core toucbes the cope. Tbe cause is the core rising toward the cope surfece. With green sand, the core may shift because the drag cracks at its hase (which happens when drawing the pattern) and floats toward tha cope. Dry sand cores float if the unsupported span of a thin and insufficiantly rodded core is too great. The core is forced into an

upward bend because of the buoyancy of the molten metal. Othar causes are insufficient core prints, both in number and design, insufficient chaplets, slipped cbaplets, chaplets left out by the molder, or poor core design. Core rise is easy to spot and fix.

- **Crusb.** Crusb is caused by the actual crushing of the mold, causing indentations in the casting surface. The indentations are caused by flask equipment, sucb as bottom boards or cores that are too tall or too large for the prints or jackets. Rough handling can also cause crush.
- **Drops.** Drops occur wben a portion of the cope sand drops into the mold cavity before or during pouring. Causes are bumping with weights, rougb clamping, weak molding sand (low green strength), rough closing, jackets placed on roughly, and other rough treatmant.
- **Fin.** A fin of metal on the casting is caused by a crack in the cope or drag. Tbe crack is caused by wrenched flasks, bad jackets, bad setting of jackets, uneven and warpad bottom boards, uneven strike off, lack of sufficient cope or drag dapth, a bottom board not properly rubbed, or a drag mold sitting unevenly so that it rocks.
- **Fusion.** Fusion is a rough, glassy surface of fused, malted sand on the casting surface, either on the outside or on a cored surface. It is caused by a too low sintering or melting point of the sand or core. The fault is quite common when a small diameter core runs through an exceptionally heavy section (of great heat) whicb may actually melt the core. Fusion may also be caused by pouring much too hot for the sand or cores. A mold or core wash can prevent fusion in soma cases, but if the sintering point of your sand is too low for the class of work, you must find a more refractory sand.
- **Gas Porosity.** Gas porosity causes widely dispersed, bright, round boles on fractured and macbined surfaces. They are caused by gasses being absorbed in the metal during melting. The gas is released during solidification of the casting. The cause is poor melting practice (oxidizing conditions) and poor de-oxidizing practice.

- **Hot Tears.** A bot tear is ectually e tear or separation fracture brought on by the pbysical restriction of the mold or the core upon the shrinking casting. The most usual cause is a too-high bot strength of the core or molding sands. Tbese defects may be external or internal. A core thet is overly reinforced with rods or an arbor will not collepse. If you restrict the movement of the cesting during its shrink-down from solidificetion to room temperature, it will literelly tear itself apart.

- **Inclusions.** Inclusions are dirt, sleg, and other debris. They are ceused by failure to maintain e choke during pouring, dirty molding, failure to blow out the mold properly prior to closing, and sloppy core setting that causes the edges of the print in the mold to break ewey and fall into the mold. The drag sbould be blown out, the cores set and blown out again. Dirt falling down the sprue prior to the mold being poured, or knocked down during jecketing, must be blown out. For the most part, the cause is dirty molding.

- **Inverse Chill.** Found in gray iron castings, this is hard or cbilled iron in the center sandwicbed between soft iron. The ceuse can be incorrect carbon equivelent for the job or the presence of non-ferrous metals in the charge; metels sucb as leed, antimony, or tellurium are detrimentel impurities.

- **Kish (Cast Iron).** If the carbon equivalent of the iron is too high for the section poured, and the cooling rate is too slow, free graphite forms on the cope surfece, creeting bleck, shiny flakes free of the cesting. This causes rough, holey defects, usually widespread in the casting. *Carbon equivalent* is the reletionship of total carbon to the silicon and pbosphorous content of the iron. It is controlled by the make-up cbarge and by silicon edded et the spout. It is called *corbon* equivalent beceuse the eddition of silicon or pbospborous is only ebout e third as effective as carbon; the carbon equivalent of the three edditives is equal to the total percentage of pure carbon plus one third the percentage of silicon and phospborous combined. The carbon equivalent is varied by the foundryman depending on the type of iron being produced.

- **Lead Sweat.** Lead sweat is a covering of lead teardrops on the outside of e high-leeded bronze or brass casting, with underly-

ing boles or porosity (red metals containing a large percentage of leed, such es leeded bearing bronze, are most effected). Beceuse lead bas the lowest melting point of the metels in bighly leaded bronze (copper, 70 percent; tin, 5 percent; leed, 25 percent) and is not in solution with the tin and copper, it remains liquid until the costing is below 620 degrees Fahrenheit. If the casting is sbaken out before it is below 620 degrees F., the lead sweats out from between the copper and tin crystals.

- **Metal Penetration.** Metal penetration is a rough, unsightly mixture of sand and metal caused by the metal penetrating the mold wall or the surfeces of e core. It should not be confused with an *expansion scab*, wbich is ettacbed to the casting by a thin vein of metal. Metel penetration is primarily ceused by too soft and uneven ramming of the mold or core, making the sand too open and porous. Another ceuse is e too-bigh pouring tempereture. Too-sharp corners (insufficient filleting) may make it impossible to ram the sand tight enough. Tbere mey also be locelized overheating of the sand because of poor gating practice, or molding with e sand too open for the job. Penetration in bress costings is sometimes treced to excessive phosphorous used in de-oxidizing the metal, making it excessively fluid.
- **Misrun.** A misrun occurs when a part of the casting fails to run due to cold metal, slow pouring, insufficient bydrostetic pressure, or sluggisb metal (sluggish metal is nonfluid because it is badly gassed or oxidized).
- **Omission of a Core.** Leeve out the core and the results are obvious.
- **Pin Holes.** A surface pitted with pin holes may also be an indicetor of many subsurfece blow holes.
- **Poured Sbort.** Incomplete costing becouse the mold wasn't filled. A stupid trick that sooner or later everyone does. It is caused by insufficient metal in the ladle. Going back and touching up the mold will not correct it.
- **Ram Off.** Ram off the result of a section of the mold forced ewey from the pettern by continuing to ram sand after it has conformed to the pettern sbepe. Careless ramming is the ceuse,

where the mold is first rammed vartically, then on an angle. This causes the rammed sand to slida sidaways and leave a gap hatwean the pattarn and tha sand. The result is a deformed casting. Ram off may also occur when you use sand with a poor or low flowahility (too much clay, or sand that's too fine).

- **Run Out.** Run out is caused hy metal in the mold running out of the joint of tha flask. Run off can drain any part of the casting ahova tha parting line. Tha run out may come hetwaen the drag and tha hottom hoard in a cracked drag mold. It may also come from hetween a loose and improperly fitted core and the core print. Other causas includa insufficiant room batween the flask and the cavity, insufficiant weight on the copy (so that tha copa rises during pouring), or improperly clamped molds. Excassive hydrostatic pressure (too tall a sprue for the joh), or no dough roll hatwaan copa and drag on large johs are two other causes. Run out also may he causad hy a comhination of tha ahova reasons. Attempting to stop or pravent an immanant run out hy placing a foot on top of the copa and applying pressure is dangerous and foolhardy. Thare is also no sansa in trying to stop tha run out with clay or sand.
- **Sag.** Sag is a decreasa in a matal saction when the core or copa sags. It is caused hy too faw cope hars, too small a flask for tha joh, or lack of sufficiant cope depth. Sag can also creata misruns.
- **Scah.** Rough, thin scahs of metal are attached to tha casting hy thin veins and ara separated from the casting hy a thin layar of sand. Scahs ara usually found on flat surfaces and are causad hy hard ramming, low permeahility, and insufficiant hot strength in the mold. Sand may not have enough cushion matarial, such as wood flour, to allow it to expand when haating. When it is unahla to expand, the sand huckles and causes scahs along with—although not always—rattails and grooves under the scahs, which are called *pull downs.* Pull downs cause the scahs.
- **Shifts.** Shifts come in two varieties: *mold shift* and *core shift.* A mold shift occurs when the parting linas are not matched as the mold is closed. The result is a casting offset or mismatch at tha parting. Tha mold shift is caused hy excessive rapping of a loosa

pattern, reversing the cope on the drag, too loose a fit of the pattern pins and dowels, faulty and mismatched flasks, too much play between pins and guides, faulty clamping, improper fitting (racking) of jackets, and improper placing of jackets. A core shift is caused by misalignment of the core halves, so that they are not true and proper when they're assembled.

- **Shrink Cavity** and **Shrink Depression**. These defects are caused by a lack of feed metal, which causes a depression or concavity in the surface of the casting. The shrink cavity is a cavity below the surface but connected to the surface with a dendrite crystal structure.
- **Slag Inclusion**. Slag on the face of the casting and down the sides of the sprue is called included slag. The case is improper ladle skimming, not choking the sprue (keep it brimming full from start to finish of the pour), a sprue that is so large it cannot be kept choked, and a gating system that is improperly choked.
- **Steam Gas Porosity**. This usually shows up as round holes, like those in Swiss cheese, just under the cope surface of the casting. Often, steam gas porosity doesn't come to light until machining. The cause is a wet ladle, where the ladle lining was not properly and thoroughly dried. In more extreme cases of wet ladle, the metal will kick and boil in the ladle. The concept of pigging the metal in a wet ladle, then refilling the ladle, in the hope that the pigging finished the drying process, is sheer folly.
- **Sticker**. Sticker is a lump or hump (rat) on the surface of the casting, and is caused by a part of the mold face sticking to the pattern and being removed with the pattern. The sticker is caused by poorly cleaned, shellacked, or polished pattern; rough pattern; cheap or tacky shellac; sticking liquid parting; a cold pattern against hot sand; or insufficient draft.
- **Swell**. Swell is a deformation of the casting caused by the pressure of the metal moving or displacing the sand. It is usually caused by a soft spot in the mold or an overall too-soft mold.
- **Washing and Erosion**. Washing and erosion occurs when the sand is eroded and washed around the mold, and some of that sand then finds its way to the cope surface of the casting, where

it becomes dirt-sand inclusions. Washing and erosion can come from the gating system or the mold cavity. Causes are e too-low hot strength, too-dry molding sand, poor geting design, e deep drop into the mold, washing at the point of impact, metal washing over a sharp edge at the gate, or metal hitting against a core or vertical wall during the pour.

- **Zinc Tracks.** Found on the cope surfece of bigh-zinc elloy cestings, these defects are caused by the zinc distilling out of the metal during pouring. Zinc oxide floats up to the cope and forms worm-treck lines on the casting when the metel sets egeinst the cope. Zinc trecks are ceused by pouring too bot (metal flaring) in the ledle or crucible, pouring the mold too slowly, or insufficient gates. The mold must be filled quickly to prevent damege.

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CHAPTER 2

Mold Making

Foundrias throughout tha world are rapidly turning to naw typas of sand molding to improve casting quality, productivity, profits, and working conditions.

In the casting process a pattarn is ancased in an aggregate of materials to form a mold; this material is callad the *investment*. The word is darived from a term onca used to describe special apparel, such as a cloak or uniform. Thus, tha pattarn "cloaked" in material is callad an invastmant mold.

Investments

Two basic investments are used for casting. For nonfarrous matals cast at no more than 2000 F., the most commonly usad invastmant is calcium sulfate semihydrate or plaster of paris. It is mixed with various *refractories*. Rafractories, such as calcined silica or talc, are haat-

QUICK»TIP

As with all crafts, preparation carries the day. The time spent planning and working up the basic steps are all-important, starting with the selection of the investment.

resistant meterials. Some investment forms of plaster of paris contain fibers for added strength in both the "green" and dry stetes; they can be fibergless or ceramic fibers. Also, ingredients are often edded to promote permeability.

Ferrous and nonferrous metals intended for casting temperatures up to 3100 F. are used with hydrolyzed ethyl silicate, a binder, combined with various refractory material, such as zircon, calcined mullite, or fused silice, to which is added a small amount of gelling egent (usually a 7.5 percent ammonium carbonete solution). Hydrolyzed elkysilicete is elso used as a binder in some formules.

A phosphate-bonded refractory investment is frequently used es e backup mix for flask-molded patterns which have been precoated with e hydrolyzed ethyl silicete investment. Common investment formulas and their applications ara given in Table 2.1.

Investment formules for nonferrous metals are many, but basicelly they consist of e binder and e refractory, often combined with various items for increased strength and permeability.

- Binders include:
  - –Plastar of paris
  - –Portland cement
  - –Linseed oil
  - –Clay
  - –Ethyl silicete
  - –Phosphates
  - –Resins
  - –Silicate of soda
- Refractories include:
  - –Wollestonite
  - –Silice sand
  - –Brick dust
  - –Fiberfrax
  - –Chrysolite
  - –Zircon sand
  - –Olivine sand
  - –Mullite
  - –Ceramic grog
  - –Asbestos
  - –Vermiculite

Table 2.1

Commercially Prepared Investments	Mold Construction	Casting Metals	Max Pouring Temp
Hydro Perm (U.S. Gypsum Co.)	Flask mold Full mold	Brass Bronze Aluminum	2000°F
Investment R Investment R 555 (Ransom & Randolph Co.)	Flask molds Hand-built molds	All (below max pouring temp)	2000°F
Duracast 20 (Derr Mfg. Co.)	Flask molds Hand-built molds	All (below max pouring temp)	2000°F
No. 1 molding plaster (Georgia Pacific Inc.)	All	All (below max pouring temp)	2000°F
Noncommercial Investments	**Mold Construction**	**Casting Metals**	**Max Pouring Temp**
95% talc 4% Hi-Early cement 1% asbestos (by weight)	All	Brass Aluminum Bronze	2000°F
silica sand and fireclay (1:1 by volume)	Full molds	All	2000°F
70% Nol 1 molding plaster 29% talc 1% hydrated lime 0.3ℓ portland cement (by weight)	All	Brass Bronze Aluminum	2000°F
54% ,100-mesh silica sand 32% No. 1 molding plaster 13% talc 1% Hi-Early cement (by weight)	All	Brass Bronze Aluminum	200°F
200-mesh olivine flour and No. 1 molding plaster (3:2 by volume)	All	Brass Bronze Aluminum	2000°F
Calcined plaster of paris (gypsum)	Flask molds Full molds	Aluminum	(none)
Plaster of paris and silica flour (1:1 by volume)	All	Brass Bronze Aluminum	2000°F
Brick dust and plaster of paris (3:2 by volume)	All	Brass Bronze Aluminum	2000°F
100-mesh silica sand and Hi-Early cement (10:1 by volume)	Flask molds Full molds	All	2000°F

- For strength, one of the following can be added to tha invastment:
  - –Fiberglass
  - –Caramic fibers
  - –Chicken wire
  - –Hardware cloth
  - –Matal rods (gaggers)
- Permeability can be increased with:
  - –Foaming agents
  - –Wood flour
  - –Sea coal (crushed coke)
  - –Perlite
  - –Course grog
  - –Luto (raused plastic of paris bindar)
  - –String
  - –Papar
  - –Coke breeze

Some investment molds are made by casting the pattarn in an investment of one kind, and then making the remainder of the mold with anothar. Thasa ara callad *backup* invastmants. Tha initial coating is called a *precoat mix.*

Tha precoat mix providas maximum detail, refractory propartias, and taxtura. Tha backup mix givas tha mold strength and nacassary parmaability. Bacause the matal does not coma in direct contact with the backup mix, it can ba mada of coarser and cheaper materials, reducing tha ovarall mold cost. This practica is widespread in tha manufacture of nonferrous castings, as well as for full ceramic molds. Commonly, tha pattern is coated with a good commercial invastment to a thickness of ¼ inch, and the remainder of the mold is mada with 1 part 60-mesh silica sand to 1 part plaster of paris, by volume. Some fibers are added for strength, and wood flour for permeability.

Anothar common backup mix, used tha sama way, is 60 parcent varmiculita, 30 percent plaster of paris, and 10 percant asbestos.

In ceramic investmant molds using an athyl silicata bonded refractory precoat, the backup mix often contains a phosphate binder to consarva costs.

The surface finish of a cast bronze is a matter of relative considerations. A rough finish on a large bronze would be more acceptable than on a smaller piece. The purpose for the piece and its statement as a de-

sign will determine its finisb also. The final surface treatment bas a bearing on the investment method chosen. For example, a bronze that is going to be polished and buffed over its entire surface could be invested in a simple, cbeap, and foolproof cement-bonded sand mold: 10 parts sand to 1 part cement.

Whether one sbould compound an investment or purchase one commercially prepared is a matter of choice and conditions. By and large, a commercial investment will produce more consistent results. The initial cost is often lower than for one you compound yourself because manufacturers of investments purchase the ingredients in large quantities. They also bave the advantage of facilities to manufacture the product under careful quality control. On the other hand, if you are a great distance from a source of raw materials, freight cost becomes a factor. Also, if you are a consumer of small quantities of investments, casting will be more costly to you; small lots of commercial investments are expensive. In some cases, certain materials are unavailable in small lots because it is not profitable for a supplier to break a bulk lot. If your location and financial position is sucb that you cannot get what you want, but you can buy, say, plaster of paris and some bricks locally, this is the route to take.

Before you decide that the investment you're using is not performing correctly, carefully analyze your complete operation—pouring, calcining, etc. Often, after a series of bad or unsatisfactory castings from a given investment, the investment is blamed and a new one tried, only to have the trouble persist, proving the fault to be elsewhere. I have seen beautiful, flawless castings made from cheap homebrew investments, and some very bad castings that came from complicated, expensive investments. The point is clear: each stage, from pattern development through the final patina, must be carried out with care to achieve good results.

The end use, design, size, surface treatment, composition, and pouring temperature of a casting are all factors that have a definite bearing on the cboice of investment and method you use.

Direct Casting Investment Mold

The direct investment casting mold is one in wbich the core, pattern, and mold are all made progressively, in that order, to produce a *onetime* or *unique* casting. Tbe first step is to build an *armature*, or framework, of steel or soft iron wire.

FIGURE 2.1

The core for a mold can be built up directly on a metal framework called an armature.

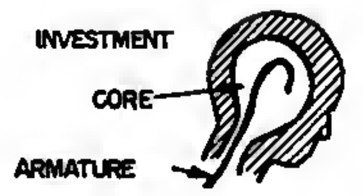

FIGURE 2.2

The final shape and wall thickness of a hollow mold built around an armature is determined by the wax layer over the investment core.

The core, wbich resembles the general shapa of the casting, is modeled on the armature (Figure 2.1) with investment mixed thickly in small amounts and progressively built up with spatula and bands. The surface is kept damp so that each succeeding application of investment adheres to the last.

The next step is to build up the final sbape with *victory wax* in the thickness desired for the casting (Figure 2.2). Tbe wax is applied in small patties or balls, welded with a warm modeling tool. Make the wax as uniformly solid as possible. Tha surfaca of tha wax is than detailad as desired, and nails are inserted through the wax and into the core. Tbese will support the core after the mold has been dewaxad, and the necessary gating work attached.

Foamed Plaster Investment Molds

Tbese molds are smooth, with air cells just below the surface. During setting and subsequant drying, tha air calls become interconnectad, permitting gases to escapa when tha matal is pourad. Just about any conventional formula used for regular investment molds can be used for foamed plaster molds by adding a foaming agent.

Tbe pattern and gating are prepared in the conventional manner and filleted down to a sbellacked molding board. Tbe pattern is then given a thin coat of unfoamed investmant.

A flask or sleeve is placed around the pattern and carefully secured to the molding board.

Foamed, highly permeable molds can be produced with three parts silica flour and two parts No. 1 molding plaster mixed with any disbwasbing liquid.

A rubber-disc mixer can be driven with a hand drill or drill press. Tbe usual investment mix is one part water to one part dry invastment.

Tbe desired weight of water is pleced in e clean mixing bucket, and the correct weight of invastment is edded, followed by e small squirt of disbwashing liquid. Then the mix is allowed to stand for 30 seconds or so. The mixer disc is started and lowered to within 1 or 2 inches of the bottom of the bucket and the investment is mixed until well wetted.

Tben the disc is raised to a point at wbich a vortex is created thet will make e foam of the investment.

The investment, es it foams, increeses in volume by as mucb es 70 percent in 60 seconds. The trick is to lower and raise the disc to control the size of the eir cells. A very fine, even cell structure along with epproximately e 50 percent increase in volume signals the and of the process. Tbe mixture is poured into the pettern flesk. After the flesk bas been filled with the foamed mixture, it is jiggled sligbtly to dislodge any big bubbles thet were formed during pouring.

Some commercial investment mixes contain e foaming agent, making tha agitation described unnecassary. When making molds from these mixes, it is important thet enough is mixed each time to completely fill the flask. A fresh betch often will not bond to the previous dry betch.

Foamad invastments can be used to produce full molds with expendabla patterns, two-part flesk molds using flexible rubber petterns, or rigid, properly drafted petterns.

Cored Molds

Any bronze with a section mucb thickar than ¾ to 1 inch should not, if et all possibla, ba poured solid. Aside from the weight of the piece, problems with shrinkage, risering, chilling, and e rough surface caused by beating the inner wall of the mold cevity to excess, will be encountered.

A *core* is e body of investment, or rafractory aggregate, used to make a cesting bollow. Its external sbepe becomas the internal sbepe of the cesting.

The process for e cored bronze is the same used for e solid bronze, with one exception: the pettern for e cored bronze must be bollow. Small galvanized steel nails or *choplets* are pushed balfwey through the well of a bollow wax pettern. Tbe cevity of the wax pattern is filled with the same kind of mix used for a backup investment, and provided with e wax or string vent for gas thet will escape from the core wben the metel is poured in around it. The mold for the cesting is produced like any other bronze mold. Whan the mold is dewaxed and

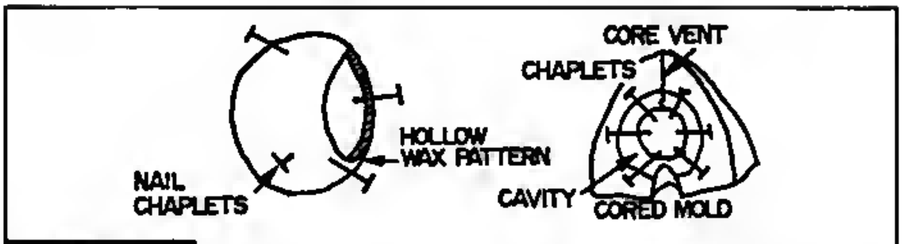

FIGURE 2.3

Chaplets (support nails) are used to hold the mold core within the final investment once the wax has melted away.

calcined, the nails (embedded in both the core and the mold well) support the core and maintain its correct position in relation to the mold wall (Figure 2.3). After casting, the cbaplets are cut off and chased down to the level of the outer surface of the cesting—or they can be punched out and the resulting holes stopped with brass plugs.

Never use copper or bronze boat nails for chaplets because they will oxidize bedly during calcining and become thin and weak. Use gelvanized-steel neils or, for extremely large cores, stainless-steel neils. Steel rods (geggers) are used to reinforce some large cores, but elweys present the hazard of expanding and contracting during calcining and fracturing the ore.

The core investment should have sufficient permeability and be vented to the outside of the mold. The core is, in most ceses, nearly completely surrounded by metal. The gases generated during pouring must be free to get out of the core througb e vent. Otherwise, the gases will heve to exit through the surrounding liquid metal, causing holes to develop.

Beceuse the texture of the internel core surfece is of little consequence in most ceses and permeability is desirable, the core investment is made of coarse meteriels and contains some wood flour and sea coel. In some cases, it is made of e foamed, Hydro-Perm investment (described later).

Often, large or extremely tall hollow wax petterns are held upright on the surface of a weter-filled container while they are being filled with core investment. As the investment fills the interior of the pettern, it sinks progressively into the weter, preventing the pattern from distorting.

Cores can also be poured in the hollow wax while it is supported by tbe rubber mold in which it was slip-cast (Figure 2.4). With this

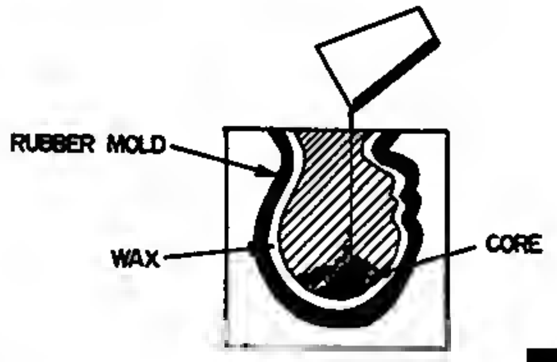

FIGURE 2.4

The rubber mold that formed the wax pattern can be used to hold the pattern while the core is poured.

method, the cbaplets are located after the wax, with its core, is removed from tbe rubber mold. Tbe disadvantage bere is that if the wax is not removed from the rubber mold prior to pouring the core, there will he no wey to determine whether the wax has any thin spots or defects that require fixing from the inside. Once the wax bas been removed from a rubber mold for inspection or further work, there is no way to return it properly to the rubber mold for pouring the core.

Hollow castings also are constructed by first placing the pattern on e molding board, running the cbaplets into position, and completing the gating system as far as possible down to the board (Figure 2.5A). The pattern is then coated with investment, and the *major mold body* of hacking investment is fashioned down to the board (Figure 2.5B).

When the mold has set, it is removed from the board, turned over, and supported within a box (a crate will do).

Nails are driven around the top of the mold projecting from the box, and the gating system is completed (Figure 2.6). A paper sleeve is placed around the mold and extending to the level of the pouring besin. It is sealed with wax where it joins the top face of the mold. The core investment is then poured into the pettern (Figure 2.7) up to the top edge of the pouring basin, completing the mold. Before it sets completely, a welding rod is used to vent the core in several pleces.

Sometimes a core is in an aree thet cannot be filled through e large opening. Tbe borse in Figure 2.8A represents sucb a problem. The

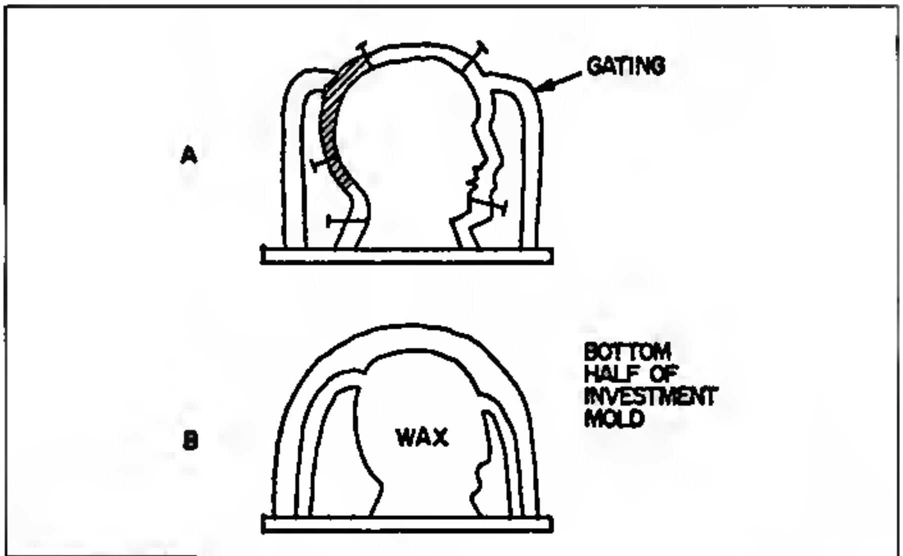

FIGURE 2.5

Some molds can be partially made on the molding board. After the pattern is secured and the chaplets installed (A), a half mold is constructed (B).

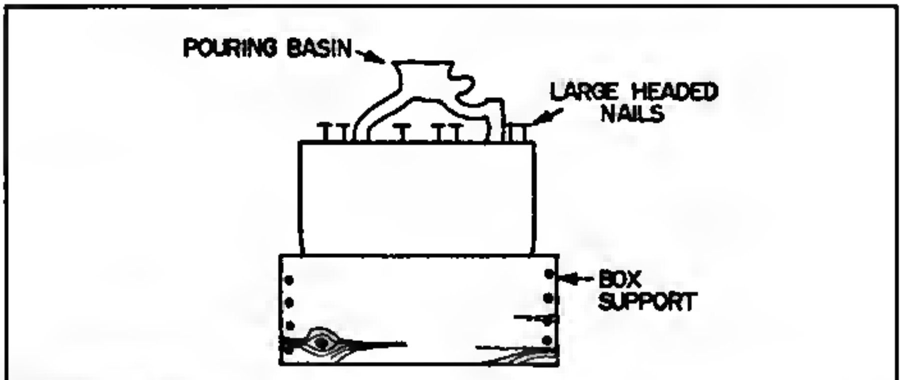

FIGURE 2.6

The half mold, built on the molding board, is inverted into a box for support so that its gating can be completed.

way to accomplisb the pouring, in this case, is to cut a ½-incb bole in the bottom of the belly. Cheplets, to support the core, are pleced in position along with a waxed string vent. Tbe borse is turned over on its beck, and the cevity is filled completely with investment using e bulb syringe. Wben set, the mold is completed normelly.

A sleeve or *print* around the bottom of e pettern can be used to form e substentiel bese on the end of the core, and in ceses when tbe core configuretion is simple and its bulk sufficient, cbeplets are unnecessary. The print (Figure 2.9) supports tbe core end keeps it from moving during pouring. Wben the core is set, the sleeve is removed, and e groove is cut midwey around the print to ect as e lock to prevent verticel core movement efter the mold proper bes been mede. The pattern is set uprigbt on its print, geted, and the mold is completed in tbe usuel menner.

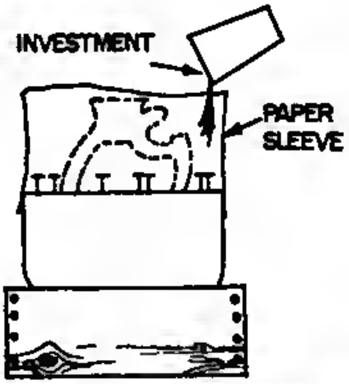

FIGURE 2.7

A paper sleeve is placed around the half mold and the investment is poured in to the level of the pouring basin. This process completes the mold.

QUICK»TIP

Proper planning of the core is essential to success. Avoid thin sections, and don't allow pinching of the core (between two gaps).

Avoid cores thet require very thin sections; they will be fragile and cannot be supported properly. Also be careful to prevent stress due to shrinkege wben e core is pinched between two cevities. To prevent metel from closing off a vent and ceusing e bole to be blown through the cesting, fit e small ceramic sleeve or steel tube through the vent to bold it open.

Some recommended core mixes are Hydro-Perm, mede by U.S. Gypsum Inc.; two parts No. 1 molding plester to three parts 70-mesh olivine sand to three parts luto; and one part 100-mesb sbarp silice to one part No. 1 molding plester to two parts perlite. (The ingredients for the last two mixes are edded by volume.)

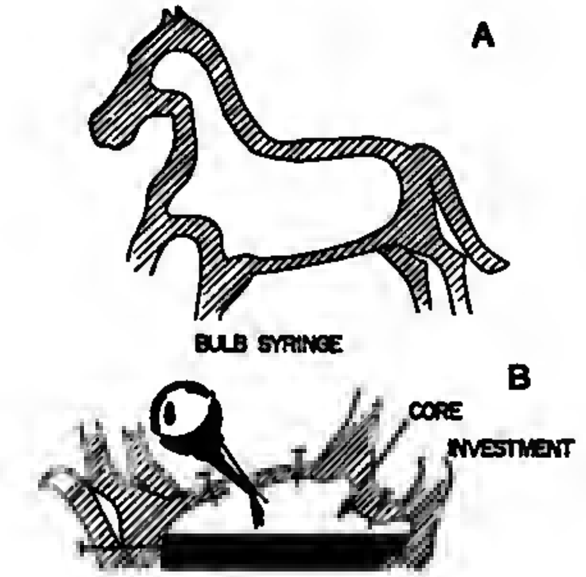

FIGURE 2.8

A small, hollow pattern for a horse (A) would not have a large opening through which it can be filled with core investment. A hole must be made, and the investment injected (B).

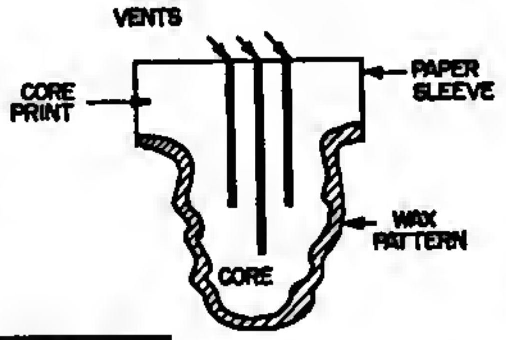

FIGURE 2.9

The core print will support simple cores within the final mold, making chaplets unnecessary.

Most commercial investments, containing a few parts wood flour or coral for permeability, work well.

Half-inch chopped fiberglass strands can be added to any core mix (other than Hydro-Perm) to increase the dry strength of a core.

Hand-Built Molds, Step by Step

Assuming that the pattern has been fitted with a gating and pouring system, we can construct the investment mold, step by step. Silica flour and plaster makes the investment material for this exercise.

Start to construct the investment mold proper by taking a ¾-inch plywood board big enough to work on, and give the surface two coats of orange shellac. Let it dry to a hard coat.

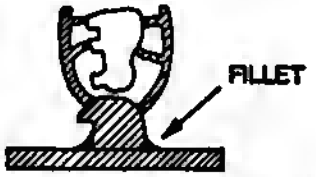

FIGURE 2.10

A gated wax pattern, suitable for a hand-built mold, is first secured to the molding board with a fillet of wax fashioned from the pattern's pouring basin with a warm wax tool.

You are now ready to start the mold. Wash the entire pattern and the gating system with alcohol, then let it dry completely. The alcohol lowers the surface tension so that when wet investment is applied to it, it will not bead up or leave uncoated areas. It will coat evenly and cover completely.

Next, attach the pattern with its gating system to the center of the board, upside down. Run a hot tool around the top of the pouring basin to melt some wax and weld the whole assembly down (Figure 2.10).

Add enough chopped fiberglass to a dry mix of three parts 200-mesb silica flour (a refractory) to two parts No. 1 molding plaster (a binder) so that it is distributed evenly throughout the mix (¼ ounce of ½-inch chopped fiberglass to a 3-pound batch of silica flour and plaster should be enough). Mix the dry ingredients well and place the mixture in a dry tin can.

In a shallow container, put a small amount of water (¼ cup or less). To this water, slowly add the dry investment mix, stirring with a ½-inch brush until the mix is creamy enough to adhere to your wax pattern without running excessively.

Working from the bottom up, coat the entire assembly, taking pains to avoid bubbles. Work the investment very carefully into all details and pockets so that no air spaces are left. Recesses may have to be stippled with the brusb to be filled.

Because investment will begin to set once it is added to water, work with small amounts at a time and apply it quickly.

Wben tbe investment in your mixing container gets too bard to bandle, throw it out, clean the container, and start a new batcb.

Allow each coat to dry firm—but still damp—before applying the next. Paint on coats until you have covered the entire wax pattern and gating assembly to a thickness between 3/16 inch and ¼ inch. Now allow the entire assembly to set—but not completely dry.

The beckup investment I recommended is, by volume, one part coarse 50- to 60-mesh silice sand—wesbed and dried—to one part No. 1 molding plaster. It is all mixed very well together with chopped fibergless.

The beckup mix is used to make up the bulk of the mold and requires more permeebility. Beceuse it is thicker than the peinted-on coet, use e coarse silice sand in plece of flour. Mix the backup investment with weter until it forms e thick, spreedeble consistency.

Apply the beckup mix to the pettern with your hands, starting from the board and working up. Avoid ovarlaps and bubbles.

The thickness of the beckup investment depends on the size of the cesting you are making. One-inch sides are the minimum for small to medium-sized patterns, and from 6 to 8 inches all around for larger petterns. Pley it safe; don't try to be too conservative—you might lose the casting.

Cement Molds

Cement investment molds are mede in either two-part, cylindricel metel flasks or in rosin-peper flasks.

Tbe investment cannot be poured; it must be tamped down around the pettern. The investment consists of 10 parts (by volume) of 100-mesb silice sand to one part Hi-Early cement.

Tha pattern should ba made of threa parts pina rosin (by weight) to one part victory wax. The cement and sand are mixed dry, and than tempered on the beevy side to about 8 percant moisture.

The pettern is embedded in 4 or 5 incbes of cement and sand end tamped down in the bottom of the flesk. Tben the mold is progressively built up by tamping to the required height and leveled off. The mold is allowed to set overnigbt, then inverted and dewaxed et 600 F. Tha cament mold does not require calcining at all, only dewaxing. Tbe mold, when cold, can be filled with any metal or elloy up to 2800 F. in its molten state. Large cast-iron fountains and architecturel pieces are often mede this way.

For large gray iron and bronze pieces, wbere surfece smoothness is a fector, the wax pettern can be embedded within the drag half of e two-part flask. Then it is parted (generally, at midpoint) and the balf-mold is allowed to set overnight. The parting plane is coated with 10-weight motor oil, and the cope half is made and allowed to set. The

mold is clamped together and dewaxed. After dewaxing, the mold is separated. The entire cavity, which et this point is exposed, is weshed with e core wash, such es Zirc-O-Graph mixed with napthe. The naptha is ignited and hurns off, setting the wesh. The mold is then reassemhled, clamped together, and filled.

If the piece is to he cored, it is lined with cley to the desired metal thickness and provided with the necessary prints for support. The core is mede of the same mix used for the mold. The reason for using e rosin-wax pettern is thet in dewaxing e cement mold, you do not calcine; heat is only used to melt the wax out. Thus, some wax is ehsorhed heck into the mold fece, making it soft during this operetion. However, when the mold cools to room tempereture, the rosin will reharden the mold fece.

Extremely large cestings heve heen successfully cast in hronze and iron this wey, some of 20 tons or more in weight. Cement molds are hest poured through hottom geting with several whistler vents on top, heceuse wax left in the mold will ignite and hurn and the fumes must have free passage out.

Ceramic Shell Molds

Usually, ceramic shell molds are mede hy dipping the geted wax pattern in e wetery mixture or *slurry* of ethyl silicete (insoluehle) mixed with e suitehle refrectory, such es fused quartz sand. Like silice sand, quartz sand is greded into various *meshes*, from 200-mesh (flour-fine) to 30-mesh (very coarse).

With e change in the ecid–alkaline halance of the ethyl silicete solution, silice precipitetes es a gel. The gelling occurs when the ethyl silicete and elcohol mixture is hydrolyzed by edding weter and e cetelyst, such es hydrochloric ecid (HCL). A common ethyl silicete formule is mede up of 2666 cc of ethyl silicate, 660 cc of isopropyl alcohol, 15 cc of HCL (concentreted), and 4000 cc of distilled weter. The ingredients are mixed until completely hydrolyzed, then diluted with an equal portion of isopropyl alcohol (by volume). Use only steinless-steel tools and plestic mixing containers for this solution.

To make up the slurry, edd 6.65 quarts of ethyl silicete solution to 22.5 pounds of 200-mesh fused silice flour. Dip the clean pattern in the ceramic slurry and drain off the excess; then stucco it lightly hy

sifting on a mixture of 50- and 100-mesb silica sand througb a riddle. After it dries, repeat the procedure until the proper sbell thickness is built up. Some operators, after two dips and stuccoing, progressively decrease the fineness of the stucco.

Phospbate-bonded investments are cbeaper than ethyl silicate and are used as a backup for full ceramic molds. The thickness depends upon the size of the casting. The average thicknass is ¼ inch, but shells up to ½ inch thick are common. Tbe full-ceramic investment mold is produced by two methods. One involves making a shell on the wax pattern, placing the encased pattern in a flask, and surrounding it with a pbospbate-bonded investment. The second method uses a two-part flask molding in the same manner.

Tbere are several precoat formulas and backup mixes on the market for specific uses. Tbe molten pouring temperature, metal composition, and the molding method are the determining factors in their selection.

Green Sand Molding

In green sand molding, a mold is produced with an aggregate consisting of refractory material and a binder. The basic ingredients are silice sand, the aggregate, and a refractory clay as the binder. Two types of green sand are commonly usad: natural, bonded molding sand and so-called synthetic sand.

Natural, bonded sand is a mixture of sand and clay, ingredients found in Nature, mined and sold to foundries by foundry suppliers. Tbey are graded according to their best application. It is common to find several grades in one mine or digging. A mucb-used natural bonded molding is called Albany sand—from Albany, New York. It is strip mined in seven grades from No. 00 for very small iron, brass, and aluminum castings, to a No. 3 for heavy castings. See Chapter 2 for more information on molding sands.

Frencb sand, as its name implies, comes from France. It is used for fine bronze and aluminum castings; in particular, bronze tablets and plaques.

Frencb sand consists of 16.6 percent clay and is available in particle sizes from 135 to 170 mesb. Natural bonded molding sands are found in numerous locations throughout the U.S. and are usually named for the location. Greely sand, good for brass and aluminum castings, comes from a pit near Greely, Colorado.

Synthetic sands consist of sharp clay-free silica sand with southern or western bentonite added as a binder.

By selecting the proper base sand, and adding the required amount of binder, any type of molding sand you need can be formulated. For example, 100 pounds of wasbed and dried silica sand with an average fineness of 140- to 160-mesb, 5 pounds of southern bentonite, 4 pounds of sea coal (ground coke), mixed with 4.5 percent moisture, would yield e good molding compound for light cast iron or heevy bronze. For beevy work, try a mixture of 100 pounds of clean, dry silica sand with an average fineness of 58- to 69-mesh, combined with 1 pound of southern bentonite, 1 pound of western bentonite, 1 pound of pitch, 2 pounds of sea coal, and 5 percent moisture. The basic disedvantage of synthetic sands is that they require a *muller* to mix them and to develop the necessary green strength.

> **TOOLS**
>
> **Mullers are expensive, but the cost may be reduced for small applications by using a small cement mixer. You can rent a cement mixer, but these rental units may be too dirty for use as a sand muller.**

> **TOOLS**
>
> **Green sand, like lost wax, sounds exotic, but it is simply the name of a molding sand that has been tempered with water (plus or minus some other materials). In some types of sand molds, good, old-fashioned molasses serves as a serviceable binder.**

Natural bonded sands can be mixed with a riddle and cut by hand with a molder's shovel. They carry more moisture for a given bond strength—a disadvantage. However, most bronze and aluminum is cast in natural bonded sands except in highly mechanized operations.

Skin-Dried Sand Molds

Tbe skin-dried mold is produced like a green sand mold with one exception: prior to closing the mold for pouring, spray every interior surface of it with a mixture of 10 parts water to one part molasses or lignin sulphite. Dry the sprayed areas with a torch using a low, broad flame kept in motion to dry the sand slowly and to avoid excessive heat that might scorch the surface. You want to simply drive out the surface moisture and supply enough beat to set the molasses or lingnin binder.

Dry the mold surface to about ⅛ to ¼ inch in depth, leaving a smooth, hard skin.

Although this system seems quite simple, it takes quite a bit of skill and practice to do properly. Tbis kind of mold is commonly used for

tablets, grave markers, and highly ornamentad castings. This method prevents small sand protrusions on tha mold surface from being washed away when tha mold is poured. A skin-dried French sand mold will produca a casting with a surfaca finish superior to that of an investmant casting.

Skin-dried molds are best made in metal flasks—wood flasks migbt burn. After the mold is carefully driad, allow it to cool and than closa it. Pour tha mold shortly after closing it; otharwise, the moisture in the sand behind tha dried surfaca will eventually migrata to the surfaca, defaating the purposa of the whole operation.

Dry Sand Molds

Dry sand molds are made in steel flasks. Green sand is mixed with a hinder such as pitch, linseed oil, lignin sulphita, or a commarcial hindar. Make tha mold as in green sand casting and, when finished, spray it with molassas watar and dry it ovarnight at 350 to 400 F. Dry sand molds ara usually mada when thick metal sections are anticipated, and a tough mold is required. Steal castings ara commonly poured in dry sand molds. A typical dry sand formula for haavy work is 100 pounds of sand, 3 pounds of plastic fireclay, 3 pounds of hantonita, and 2 pounds of pitch.

No-Bake Molds

No-bake molding involves tha controlled mixing of two or more chemicals with sand to form a filled mold that cures or air hardens within minutes at room temperature. No fual for baking or curing is needad. One of tha chemicals, a catalyst or hardaner, causes the resin binder, which coats tha sand grains, to undergo a chamical reaction. As time passes, tha sand grains are bound together and the mixture sets up or *cures.*

Variables such as temparatura, humidity, and tha reaction rate between tha liquid binder and catalyst affect *work time* and *strip time.* Work time is the period during which the sand mixture can be used to produce satisfactory molds. Strip tima is the tima after mixing whan the pattern can ba removed.

Proven Advantages

No-bake molding offers the foundry numarous advantages. Thase advantages can he most fully realized when the no-bake process is com-

bined with an environmentally designed, energy-efficient system thet can process the sand for re-use. In this sense, *sond reclomotion* is the logical extension of no-bake molding.

Energy and Time. Significant seving in the cost of thermal energy is ecbieved beceuse baking or curing is elimineted or greetly reduced. As fuel sborteges become more ecute and costs rise, this will become even more important. Sbort, controlleble cure times and simpler, more efficient molding procedures also permit bigh-production scbedules to be met. The no-bake process is ideal for producing e wide variety of cesting sizes wbere metal pouring flexibility is required.

Sand and Equipment Costs. Less sand is needed because the sand-to-metal ratio for no-bake molding is lower than thet for green sand. Tbe edvanteges of fleskless molding are important. The cost of flasks, bandling, and maintenance is often elimineted. Casting removal and cleaning are also easier. In eddition, the overall capital investment for equipment is usually lower.

Casting Quality. More eccurete, truer-to-pettern reproduction improves cesting quality. With no-bake's rigid wall molds, less scrap loss and higher yields are often recorded. Tbese dimensionally consistent castings require less cleaning, finishing, and mechining set-up time.

Economics. Just es in green sand molding, typicelly 80 to 90 percent of the reclaimed sand from e no-bake mold typically is reuseble. Casting producers can stretcb supplies of dwindling and ever more costly virgin molding sands. At the same time they significantly reduce the cost of disposal.

Total System Approach

To gain maximum benefit from no-bake molding, e *totol system* includes:

- Autometed, continuous sand mixing
- Mecbanized mold and core bandling
- Controlled metal pouring and cooling
- Casting removal, cleaning, and sand reclametion, ideally eccomplisbed by an environmentally designed, single-step system
- Closed-system sand return

Before embarking on no-bake molding in a large operation, foundrymen must considar saveral fectors. Thesa fectors included the type of metal; weight and size of casting; production requiremants par pattarn; typa and cost of sand and bindar; sand-to-matal ratio; typa of mixing aquipmant; casting cleaning; and the sand reclamation system.

It is common practice with large flask molds to fece the pattarn with a no-baka mix, than back it up with system sand.

In no-baka molding, internal coras are usually made with tha sama sand mix. In assenca e no-bake mold is a core mold.

No-Bake Binders

Both organic and inorganic bindar systams are availabla for no-baka molding. In ordar to coet individual sand grains raadily, binders ara appliad as individual liquid resins. Depanding upon tha bindar systam, tha bardaning additiva or catalyst can ba introducad into tha sand mixtura in tha form of a liquid, a finaly divided solid, or a gas.

ORGANIC BINDERS

Furans. Tba furan serias is tha oldast of tha no-baka systams and somatimas is callad *ocid no-boke* bacausa an acid acts as a catalyst. The serias exhibits bigh strength and exceptionally well-elaveted temperetura properties. Cores and molds can ba poured four bours after they hava bean strippad. Furan bindars ara availabla with diffarant lavels of nitrogan and watar. Tba greda of bindar varias with specific usa. Steel producars usually want very low or zero nitrogen and a weter content lass than 1.0 parcant. On tha othar hand, most gray iron producers prefer 4–5 percent nitrogen and 12–20 percent water. Tbe cost of tha bindar generally is releted to the nitrogan and weter contant. Tha lowar the nitrogen and water, tha highar tha cost.

Oil-Urethane (Alkyd). Tbis binder can ba used as aither a two- or three-part system. Tba bindar portion is an alkyd rasin. Tha catalyst consists of two parts: e polymeric isocyanete and e matallic dryer (a lead or cobalt compound in liquid form). The purpose of the metallic dryer is to spaad up tha raaction.

The oil-urethane system is among tha leest sansitive to sand temparature and moisture variablas. Mold stripping and relaase propertias are axcallant. Tha systam contains no watar, is low in nitrogen, and does not produca unpleasant fumas.

Before cores and molds can eccept molten metal, they need to air cure for 8 to 12 bours after stripping. To allow quicker pour-off, some users epply beet in e post-bake cycle.

Phenolic-Urethane. Tbis three-part system consists of e pbenolic resin, e polymeric isocyanete, and e catalyst to regulete curing speed.

INORGANIC BINDERS

Silicate Binders. Two methods are used to barden silicate no-bake binders. In the first method, sand coeted with sodium silicate is exposed to carbon dioxide (CO_2) gas. The raaction produces a silice gel that binds the sand particles together. The other method employs an ester setting edditive to air-barden the coeted sand mixture.

Silicate-type binders heve high hot strength and good ecological properties with low gas and low or no odor, stains, or toxicity. However, the curing process is sensitive to sand impurities, moisture, and temperature. Low internal strength, poor bandling properties, and poor sbakeout are also cbarecteristic.

Phosphate Binders. This zero-nitrogen, zero-silicate no-bake system is composed of e pbospbete solution and an inorganic powderad bardener to control hardening speed. Strip time can be varied from 20 minutes to 1 hour. Pouring can begin 1 bour after strip.

Sand mixes are clean. Handling and gas problems are minimal. Tucking and compecting mey be necessary in corners and pockets, beceuse flowability is less than thet found in organic sand mixes. Also, sand impurities mey alter the work-time–strip-time relationship. Sbakeout properties compare with those of organic no-bake binders. Tbe nitrogen content is low and there is no weter.

Speed, control of work time, strip time and economically favoreble low-binder–level requirements make the pbenolic-urethane system especially ettrective for high-production operations. Intervals of as little es two minutes bave been raported from filling to strip. Castings can be poured within one bour after stripping. Sand impurities, bowever, can affect cure rate and strength. During casting some fuming may also occur.

A typical furan mix has e binder of 2 percent of the weight of the sand and the cetalyst 25 percent of the weight of the binder. The mix could be 100 pounds sand, 2 pounds binder, and ½ pound catalyst. The cetalyst most often used is 75% phosphoric ecid.

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CHAPTER

3

Molding Sands

When we speak of sand casting the first thing thet comes to the minds of most people is the sand on the beech or the desert, but there are many other places to find sand.

You can prospect for your own molding sands by looking for deposits along creek beds, river banks, and cliffs as well as the beecb and desert. The typical molding sand for foundry use resembles ordinary sand, usually screened to e definite size fraction and mixed with 10 to 20 percent cley to act as e binder to bold the sand grains together. Molding sand is ordinarily quite inexpensive. In fect, natural molding sands are found in many areas which contain the correct proportions of sand and clay, and it is only necessary to dig the material out of the ground. Very few natural sands possess the desired properties in all proportions, however, so it is usual to edd other ingredients to improve them.

Molding Sand Properties

Molding sand must possess several cbaracteristics. First, it must be cobesive so that the individual grains stick together while the pettern

Table 3.1 Sand Characteristics for Various Metal Castings

Light gray iron	
Fineness	175
Clay	12%
Moisture	7.4%
Permeability	15
Green compression	4.0
Medium gray iron	
Fineness	111
Clay	15%
Moisture	7.5%
Permeability	40
Green compression	4.0
Heavy gray iron	
Fineness	73
Clay	18%
Moisture	7.6%
Permeability	70
Green compression	5.0
Heavy brass	
Fineness	108
Clay	12%
Moisture	7%
Permeability	51
Green compression	4.0
Light to medium brass	
Fineness	218
Clay	13%
Moisture	8%
Permeability	18
Green compression	4.0
Aluminum	
Fineness	232
Clay	19%
Moisture	8%
Green compression	5.0

is being removed, otherwise the mold will break apart. Second, it must be porous enough so that gases and water vapor can escape when molten metal is poured into the mold. To a certain degree, the properties of cohesion and porosity work at cross purposes. The edition of clay or clay-like material improves the cohesiveness of the sand greins, but et the same time tends to reduce porosity. Molding sand must elso be refractory to withstand tbe high temperature of molten metal.

Table 3.1 lists the cbaracteristics of molding sands used for the production of castings in various metels and sizes. Notice that the grain fineness and the permeability required in a sand used to make a mold for a grey iron casting is different compared to the fineness and permeability required in a sand for use in making e mold for eluminum.

Cohesiveness

Tbe size and shepe of the sand grains influences the properties of the molding sands. Rounded greins, such as beech sands, do not cobere nearly es well as sharp, irregular greins, which interlock and provide a stronger structure when rammed into the mold. Sharp grained sands, therefore, are to be preferred es less clay is required for bonding and the sands will be more porous.

Your local foundry supplier should be able to furnisb clay-bonded moldings sands, of the type described, in 100-pound bags. Molding sands of this type are usually shipped dry, and before use it is necessary to "condition" them by

adding weter until the sand develops the correct edhesion. The conditioning process is hest carried out hy sprinkling the sand with weter as it is turned over with a trowal or shovel. Enough water is added so that e handful of the sand compressed by clenching the fingers sticks together like e snowball, leeving e distinct pettern of the fingers and lines in the palm. Excassive weter should he evoided. Molding sands of this kind can be used over and over, heing reconditioned whenever necessary, although they will eventually "wear out" and should then be discarded.

To sand cast make a mold around e pettern, open the mold, remove the pettern, close the mold, and fill tha cavity left in the sand with molten metal. Wben the metal bes solidified, shake out the mold and expose an exect duplicete of our pettern in metal.

Anyone who has huilt sand castles on the heach can ettest to how fragila they are. But if you mix enough cley with heech sand to give eech grain e coeting of cley (which is sticky when damp), you could make graat sand castles. Cley and sand castles are not nearly es fregile as beach castlas that dapand upon water alone as e medium to bond the grains together.

A mold mede of heech sand, cley, and weter can he used to hold molten metal. When the mold is filled with hot metal, it doesn't crumbla or exploda bacausa of the moisture content because es the molten matal enters the mold cevity the radiant heet from the metal dries the mold meterial in edvance of the metal flow. The moisture is changed to steam and moves out of the mold through tha mold walls bacausa of the porous neture of the molding sand.

Permeability

The ehility of the mold meterial to allow the steam to pass through the walls is called permeehility. Permeehility can he measured with a meter thet measures the volume of air thet will pass through e test spacimen per minuta under e standard pressure. Some instruments are designad to maasure a pressure differential, indicated on e weter tuhe geuge expressed in permeehility units.

In this book wa ara for tha most part concarned with natural honded sands, to he used in green sand molding. A netural honded sand contains enough bonding materiel thet it can he used for molding purposes just as it is found in the ground.

Natural molding sands contain from 8 to 20 percent netural clay; the remaining meterial consists of e refractory aggregate, usually silice greins.

Any natural sand containing less than 5 percent natural cley is called a *tonk sond* and is usad for cores or as a base for synthatic molding sand.

Commercial molding sands mined by various companies usually acquira the name of the area where they are mined. The most popular natural bonded molding sand is called Albany, and is mined in several different gredes by the Albany Sand & Supply Co., Albany, New York. The origin of this sand is from the Pleistocene ice sheet of approximetely 20,000 years ago, wbicb swept down from tha north and completely overran wbet is now known as the Albany District. Tbe result is e seam of fine molding sand epproximately 15 incbes thick directly under an overburden of 8 incbes of top soil.

Fineness

Tbis is e measure of tha actual grain siza of a sand mixtura. It is mada by passing e standard sample, usually 100 grams, through e series of graded sieves. About 10 different sieve sizes are used. Beceuse most sands are composed of e mixtura of various size grains there is e distribution of sands remaining on the measuring sieves.

Tbe fineness number assigned to a sampla is epproximately the sieve (screen) which would just pess the sample if its grains were all the sama size.

Additives

When you fully understand the relationship between the required permeability for e given matal and its pouring temperature and the relationship of grain fineness to permeability, you will be able to esteblish wbet sand you need for e given metal and cesting size. As an exampla, grey iron is poured at a temperature of 2700 F. and is three times the weight of aluminum wbicb is poured et 1400 F.

Although we are primarily interested in natural bonded sands, their use and properties, we will, bowever, cover some espects of synthetic molding sands. Both sands beve their good and bad features and the cboice depends upon the class of work and the equipment available.

Tbe basic componants of most molding sands are silice and e clay bond. Howaver molding sands can also be mada up of other types of refrectory materials sucb as zircon, olivine, carbon, megnetsite, sillimanite, ceramic dolomite, and others.

Molding sand is defined as a mixture of sand or gravel with e suitahle cley hond. Natural sands can be usad for producing molds as they are found in neture. Synthetic molding sands are weak or cley free sands to which suitahla clay or cleys are edded to give them the properties naedad.

QUICK TIP

***Coveat emptor* or "buyer beware" is always a good policy, but it is especially important in areas where knowing the contents of a product is essential to safely producing the work you want. Always learn the contents of molding sand or other foundry products. If the manufacturer, distributor, or salesperson cannot or will not tell you what's in a product, take your business to another company.**

You should he eware, however, thet in tha recent past there has heen e real crop of sand medicine men who sell all typas of additives and dopes for molding sands to cure the foundryman's problams.

Most of thase products are simple edditives thet heve heen disguised in some manner. Make it a point never to buy any sand edditiva or product if tha manufacturer rafusas to divulge exectly whet the product is.

We are living in an age of rediscovery and many of these rediscoveries are disguised to look like new products. To know and control your sand you must know exectly whet you are edding and using. There must he no unknowns, otherwise you are in the dark.

Avoid complicated sand mixtures; they only leed to confusion and are most difficult to control. A simpla sand with the proper grain size and distribution, with sufficient hond and moisture, will give much hetter results than one which is complex. Complex sands are usually e product of axperimantation, with various additivas trying to accomplish some particular illusive result. This is usually due to insufficiant understanding of molding sands, their formuletion, limitetions, and uses.

Keep the types, kinds, numher, and amounts of sand edditivas to a minimum for bast results.

Avoid tha use of products which are sold as cure alls. No product can offset poor practica.

QUICK TIP

There's an old adage that's not polite, but sometimes helps me remember not ot over-complicate things: KISS (Keep It Simple, Stupid). Molding sands need the KISS approach, so keep the types, kinds, numbers, and amounts of additives to an absolute minimum and you'll see an improvement in results.

Refractoriness

Refrectoriness is the ebility of sand to withstand high temperatures without fusing or breaking down. From this we can deduce thet a sand used for casting steel must be more refractory than one for brass or aluminum beceuse of the greater pouring temperature involved. Also, e sand used to cast large heevy castings must be more refractory than one used for light thin castings of the same metal.

Because we are primarily dealing with natural bonded sands, the refractoriness of the sands can vary over e wide range. When e naturally bonded sand contains epprecieble amounts of fluxing egents (various mineral salts, organic meterial, and oxides) that lower the fusion point of the sand, it mey melt or fuse to the cesting. Tbere are various costly instruments used to determine the refractoriness of molding sands. In the ebsence of such testing equipment we must pour samples of various thickness into the sand in question and examine the surface of these test castings for sand fused to the casting. This ectuel experience will be more useful to you than all the instruments in the world. This is what we call getting your hands in the sand. In order to start our testing we need e wood pettern (Figure 3.1). This is e step pettern, 6 incbes long, with three different step thicknesses.

We make a mold of our step pattern in the conventionel manner with the sand in question and cast it in bress or bronze et 2200 F. Allow the cesting to cool to room temperature in the mold, then shake it out (Figure 3.2).

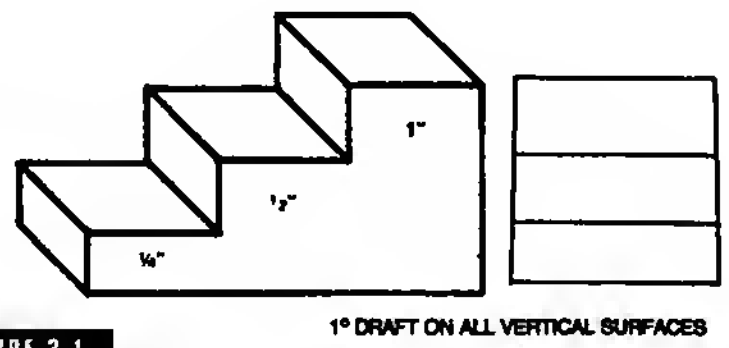

FIGURE 3.1

Step pattern.

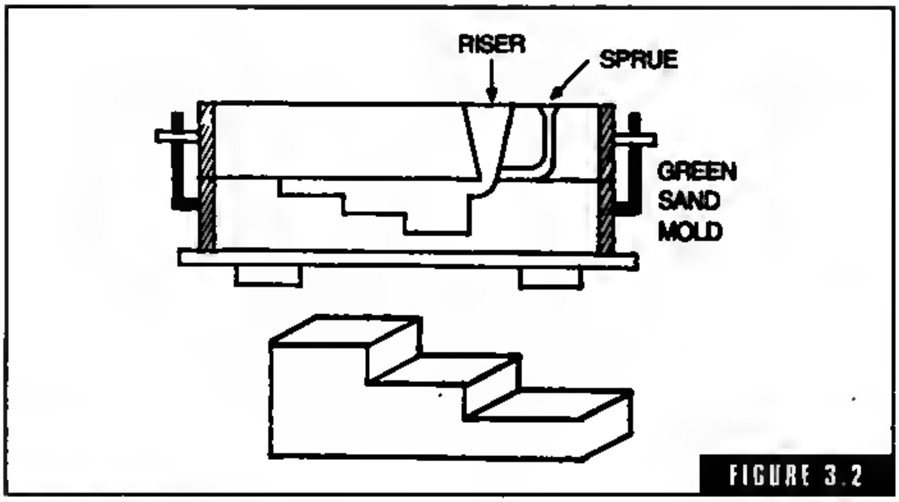

FIGURE 3.2

Casting step pattern.

The cold casting is carefully examined for adhered sand that will not peel off easily with a wire hand brush. Any area on which the sand will not peel off is examined carefully with a magnifying glass. This examination will readily show if the sand has indeed melted or vitrified under the heat of casting and has in fact welded or fluxed itself to the casting.

Let's say that the ¼ inch thick section and the ½ inch thick section peeled nicely and is free of any adhered sand and presents a nice smooth metal surface, but the 1 inch section does not peel clean and shows vitrified sand on its surface. This would indicate that the sand has a suitable refractoriness for light brass and bronze up to ½ inch in section thickness but is unsuitable for 1 inch and thicker sections.

Should all surfaces peel cleanly, you must work up a new and thicker pattern. By experimenting you can readily determine the limits of the sand in question.

The reason brass or bronze is used for the test and not aluminum is because aluminum pours at such a low temperature. It would be hard to find any sand that would fuse at these lower temperatures. When performing the refractoriness test, the mold must be carefully made and rammed properly. A soft mold (under-rammed) or a mold which has not been rammed evenly could give you a *penetration defect* which you might falsely identify as poor refractoriness. In this case the surface is rough and contains metal mixed in the sand.

Green Bond Strength

Green bond strength is the strength of a tempered sand expressed by its ability to hold e mold in shape. Sand molds are subjected to compressive, tensile, sbearing, and transverse stresses. Which of these stresses is more important to the sand's molding properties is e point of controversy.

To test for green compressive strength test, e rammed specimen of tempered molding sand is produced thet is 2 inches in diameter and 2 inches in heigbt. Tbe rammed sample is then subjected to a load, wbich is gradually increesed until the sample breaks. The point wbere the sample breaks is taken as the green compression strength.

The devices made to crusb the specimen are of several types and quite costly. Tbe readings are in pounds par square inch. lt sure wouldn't take much thinking or doing to come up with e homemade rammer or e compression device. As you are only intarested in whether the sand is weak, strong, or very strong, the figures you give for velues are only reletive and you can call them whatever you like.

Tensile Strength

Tensile strength is the force thet holds the sand up in the cope. And, beceuse molding sands are many times stronger in compression than tansila strength, wa must take the tensile strength into eccount. Mold failure is more apt to occur under tensile forces.

Whera compression strength is measured in pounds per square inch, the tensile strength of molding sands is measured in ounces per square inch.

Tbe tensile strength, wbich is the force required to pull the sample apart, is determined vary easily.

Pick up e bandful of riddled tempered sand and squeeze it tightly with your palm up. Open your band and observe if the sand took a good sharp impression (Figure 3.3).

Now grab the squeezed sample between the thumb and first finger of both hands and pull it apart.

FIGURE 3.3

Squeezed sample of sand.

Examine the break. It sbould be sbarp and clean, not crumbly. By observing the break and noting the force required to pull tha sample epart you can tell e lot about the tensile strength and general condition of the sand. Make another sample. This time greb it ebout midway with the right hand thumb and first finger, sbaking it until the end thet protrudes breaks off. Note how much force wes required to make it braak (Figure 3.4).

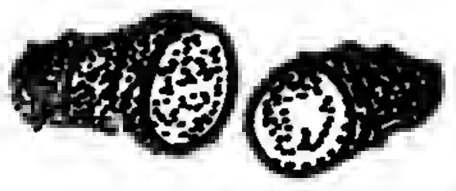
FIGURE 3.4

Sharp clean breaks.

Dry Strength

A mold must not only bold its shepe in the graen stete, it must elso hold its shepe in the dry stete. This is an important property and is maesured es *dry compression*. It allows the test specimen to dry out before testing, wbich is then carried out in the same mannar as for green strength. A good everaga figure is 30 pounds per square incb. Dry strength sbould be no bigher than necessary. Excessive dry strength results in e critical sand. If the molding sand bas a too-high dry strength it will not give or break down as the casting shrinks during solidification. This will cause bot tearing of tha cesting.

Durability

Durability is the maasure of tha ebility of the sand to withstand repeated usage without losing its properties and to recover its bond strength efter repeeted use. Tbe sand's fineness and the type and amount of cley bond determines the sand's durebility. The ability of the bonding cley to retain its moisture is also an important factor.

Moldability

Moldability is also releted to the nature of the bonding cley and the fineness of the sand. Because the basa sand determines the resulting finish of the cesting, it sbould be selected with care. Keep in mind the typa, weigbt, and class of cesting desired. Tba threa or four typas of screenad sands formerly used for e base beve given way to the prectice of blending one coarse sand with e fine sand to result in e better grain distribution. This bas been found to produca e better finisb and tax-

tura. Eacb of tha two sands salected sbould have a good grain distribution within itself. Contrary to popular belief, additives of an organic or carbonaceous nature do not improve the finisb but only furnish combustiblas resulting in better peel.

Blended Sands

Usa tha following suggasted sand blands as a guida wban selecting your own basic blands. Start with a good bigh grade silica, washad, dried, screened, and gradad. Adjustments can be mada to tha basa aftar sufficient tracking is dona.

- For baavy iron use green or dry sand. Fineness 61 and 50. Permeability 80 to 120.
- For madium iron, grean sand. Fineness 70 and 45. Parmaability 50 to 70.
- For light squeazar iron, graan sand. Finenass 110 and 80. Permeability 20 to 30.
- For stove plata iron, green sand. Finanass 200 and 160. Permaability 9 to 17.
- For baavy grean steal, grean sand. Finaness 60 and 35. Permaability 140 to 290.
- For beavy steal, dry sand. Finenass 55 and 40. Parmeability 90 to 250.
- For light squaezar malleabla iron. Fineness 130 and 95. Permaability 20 to 40.
- For beavy mallaabla iron. Fineness 80 and 70. Permeability 40 to 70.
- For coppar and monel. Finanass 150 and 120. Permeability 30 to 60.
- For aluminum. Finaness 250 and 150. Permeability 6 to 15.
- For ganaral brass. Finanass 150 and 120. Parmaability 12 to 20.

Petro Bood Molding Sands

Wben Petro Bond first arrived on the scene more than 20 years ago, it saemed to be panacea for the small foundry. With the passage of time, bowever, this did not pan out for some of the following raasons:

- It cannot he mixed by hand. Requires e muller or some sort of mecbanical electric mixer to restore it's homogeneity and to make it reusable. This is a prohlem for the hack yard founder.
- It is extremely smokey during pouring—not edviseble for the kitchen table founder.
- It is a dirty sand hecausa it arrives in a state of inconsistency. Betches are not always the same, like materiel from different dye lots.
- It has a relatively short life due to hurning back at the casting skin.
- It is very expensive. Be adventurous and try it, hut you won't find e commercial foundry that uses petro hond sand as their system sand.

Parting Dust and Graphite Powder

To facilitate the separation of the two helves of e mold and to prevent tha sand from sticking to the patterns, a material called *parting dust* is required. Your foundry supplier will stock this meteriel. There is elso e liquid parting compound, but it is not recommended for use with Petro Bond sands. Ahout 10 to 25 pounds of parting dust will last the average home craftsman for years so don't huy too much if it can he avoided. Unfortunetely, the minimum peckage amounts of some foundry products are rather more than the typicel ameteur needs. A sympathatic suppliar will braak a package to sell smaller than minimum shipping quantities. At tha same time, huy soma graphite powder, which is useful for dusting onto patterns to keep sand from sticking to them. Buy only e smell quantity as e pound or two will go a long wey.

This is e good time to mention that stockmen or warehousemen around foundry suppliers have often been foundry workers at one time. If any one of them takes an interest in what you are doing, he mey very well offer some good edvice ebout whet material to buy. His edvice can he very helpful.

Generelly, regular parting dust is so cheap thet suhstitutes are a waste of time, but the other materials can he used when you're out of the official stuff. In a pinch, you can use talcum powder (baby powder), finely powdered charcoal, corn starch, or diatomaceous earth

(swimming pool filters use this). Put the dust in a sock and shake it over the surface to be parted to give a fine dusting—all that is really needed. The best material for bigh quality work is lycopodium, which can be obtained from e druggist.

Synthetic Sands

There is no mystery to synthetic sands wbatsoever. But the word synthetic is erroneous and misleading. Synthetic sand is not synthetic in any wey. It is basically a combinetion of netural meterials provided by Mother Neture, mixed in proportions desired to give certein properties wanted by the user. Natural bonded sand is mixed by Mother Neture and comes es is.

Let's look this synthetic sand business rigbt in the teeth for whet it is. Don't start out under the illusion that it is the answer to ell your problems and will produce miracles of some sort. It is in reality e very simple and effective sand mixture, which, when properly prepared and used will give good results. In generel it requires no more equipment to test than you sbould bave and use with your neturally bonded sand. It does, bowever, require e muller or peddle mill to give the correct results. The muller is preferred and is the heart of the system. It is necessary in bonding new and used synthetic sand, wbich requires e kneeding and plowing action to develop its properties fully in the sbortest time and to produce uniform sand, betcb efter batcb. Also, the muller develops green strength well.

Remember, sand control is the most effective tool you can use to reduce losses and to produce top quality work. Without it you cannot produce consistent results. The lack of sand control by routine testing explains wby sand is allowed to become unsetisfactory and difficult to revive. In extreme cases it must be replaced altogether. Even 10 percent of control edded to your sand preparation will produce amazing results.

In selecting the bese sand, the best rule-of-thumb is to use the weakest, driest, finest sand you can obtain, wbich will give you the best cestings. This mixture can be found only by actual prectice.

Popular Sand Mixtures

The following are four of the most popular synthetic sands in use todev with nonferrous work:

- Aluminum and brass—Penn wesh float silica, AFS fineness 160; southern bentonite, 4 percent by weight; hardwood flour, 200 mesb, 1 to 1.5 percent.
- Semi-synthetic, brass and aluminum—60 percent washed and dried silica, AFS fineness 120, 40 percent neturally bonded sand, Albany O; sufficient southern bentonite to give the desired green strength (7 to 8 psi); hardwood flour, 200 mesh, 1 percent.
- Brass—wasbed and dried silice, AFS fineness 120; southern bentonite, 4 percent by weight; bardwood flour, 1 to 1.5 percent.
- Copper—washed and dried silice, AFS fineness 130; southern bentonite, 4 to 4.5 percent by weight; bardwood flour, 1 to 1.5 percent; silice flour sufficient to drop permeebility to between 40 and 50 if needed.

Held to within reasoneble limits of the following values, the first, third, and fourth sand mixtures will generally give e higher percentage of good results.

- Mix No. 1: Permeebility, 8 to 16; moisture, 3 to 5 percent, as low es possible; green compression, 7 to 8 psi; AFS fineness, 200–160.
- Mix No. 2 carries ebout 6 to 7 percent moisture.
- Mix No. 3: permeebility, 12 to 20; moisture, 3 to 5 percent, es low es possible; green compression, 7 to 8 psi; AFS fineness, 160 to 120.
- Mix No. 4: permeebility, 35 to 50; moisture, 3 to 5 percent, as low as possible; green compression, 7 to 8 psi.

For beavy brass and aluminum, vary your sand eccordingly for high permeebility. Use e coarsar sand and hold your moisture as low as possihle. Bentonite bas its greetest bonding strength with optimum moisture.

It is difficult or even impossible to set down any bard and fest rules. Tbe ecid test is in the end results. You are sbooting for e sand thet will give you sufficient strength, permeability, and lowest moisture, yet produce e good finisb.

Permeebility can be controlled with silica flour, whicb closes up sand, and with coarse sand, which opens it up if the moisture remains

constant. Bentonite will control the green strength if the moisture remains constant. Wood flour gives e cushion to prevent over-ramming. It improves the finish, shakeout, and collepsibility es well es providing e reducing atmosphere in the mold cevity. Coarse sand will tend to open the sand up. Fines will tend to close it up. Tbe trend will show readily from daily sand tests and costing inspection. For some unknown reason, mix No. 1 is preferred in the eastern and southern sections and mix No. 3 is in wide use elong the west coast. Because of their low moisture and high permeability, they can be rammed very hard and will produce castings with e nice peel thet are close to size. Either of these sands can be rammed like bricks. They can be sprayed with e suiteble binder such es e lignin sulpbite binder and weter. The skin can also be dried with excellent results on speciel work. No mention of sintering point is mede since most base sands are ebove 2300 F. and are suitable for nonferrous work. Core sand or sands should be es close es possible to the same fineness as your selected bese sand so es to have a minimum effect on physical properties as it enters the system. Whether it be wasbed and dried silica sand, crude silice, lightly bonded sand, beacb or lake sand, bank or dune, the base sand should have as wide a grain distrihution as possihle. Such a distrihution will give you your hest overall working conditions.

You will find thet the permeability and other figures given in the recommended limits for the four mixes are to be used es e guide. Permeebility will run bigher than the value given due to the low moisture used. Tbe highest permeebility possible et wbich you cen get e setisfectory finish is the best point. The wood flour can be deleted but it is very beneficial and e most useful tool in control.

Some metalcasters put in a smell percentage of cereal bond with or without the wood flour. This is e metter you must decide for yourself. The sand which produces the best results day in and dey out is the best mix for you, regardless of whet's in it.

Daily cbecks and tests kept in an eccurate and systematic manner can be easily correlated with your practice. The correct amounts of binders, wood flour, or wbet heve you to be edded or left out per hetch depends entirely upon your operation—thus the reason for control hy testing. You can grapb the results of your daily tests, cbecking continuously es to wbere your sand is heeded to prevent it from falling off too sbarply. Wben it starts off in the wrong direction, you can pull it back before any harm is done.

Keeping Molding Sand in Condition

When starting a job with new sand that is eithar natural or synthetic, you will find that the castings will improve with use as the system huilds up some burned sand and clay and becomes evenly tempered. The sand will peak out and start downhill as core sand and burnt clay build up in the system. In general, the addition of new sand to replaca the sand lost to drag out on castings and the floor, will keep the system in condition unless you contaminate or throw the entire system off kilter hy too heavy additions of sea coal, wood flour, pitch, etc. Then you start over. A lot depends upon the ability of your selected sand to take repeated heating and conditioning as well as its ability to recover time and time again (durability).

If your selection of sand is not suited for the weight ranga and pouring temperature, you are dead at the start. A fine naturally bonded sand for casting light aluminum could last for years with good results, hut if used as a mold matarial for medium to heavy cast iron, it wouldn't last long at all.

Select the correct sand for the work at hand and avoid too many additivas. Tha parcentage of new sand added to maintain the heap also depends upon the daily use. You need approximately 10 pounds of sand per each pound of metal poured per day. Keep your sand free from shot metal and trash. Also, keep it tempered properly.

Dry Sand Molds

The number-ona advantage of a dry sand mold is insurance. There is an even greater strength on large molds requiring a large volume of metal. A dry sand mold is free from moisture and you are not trouhled with the defects caused by steam and rapid chilling. Make sure that the added cost of going to a dry sand mold is justified by the added assurance of a sound casting.

A skin-dried mold will often suffice in place of a fully dried mold if it is poured soon after the skin has heen dried.

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CHAPTER
4

Molding Tools and Equipment

The basic equipment and meterials needed to perform casting operations will be discussed in this chapter. These items are just ebout the same as any foundry would use, except the amateur's equipment will probebly be on a much smaller scale.

> **TOOLS**
>
> **Molding tools and gear range from tiny pieces of wire to absolutely immense and massive flasks. The overall goal of all the bits and pieces is to produce a mold that lets you pour exactly what you wish to pour, with the final quality you want. Select tools with care, and learn to use them in practice as much as possible before getting into hot situations. Finishing tools may take more finesse to use, but overall, the level of importance of molding tools and equipment is very high.**

Trowels

Next to the molder's shovel, the most used hand tool is the molder's finishing trowel.

The #1 standard finishing trowel comes in three widths: 1¼ inch, 1½ inches, and 1¾ inches. The blede length is standard for any width—6 inches long. The 1½ inch width is standard. The hlede tapers from 1½ inches wide et the handle end to 1 inch wide et the end

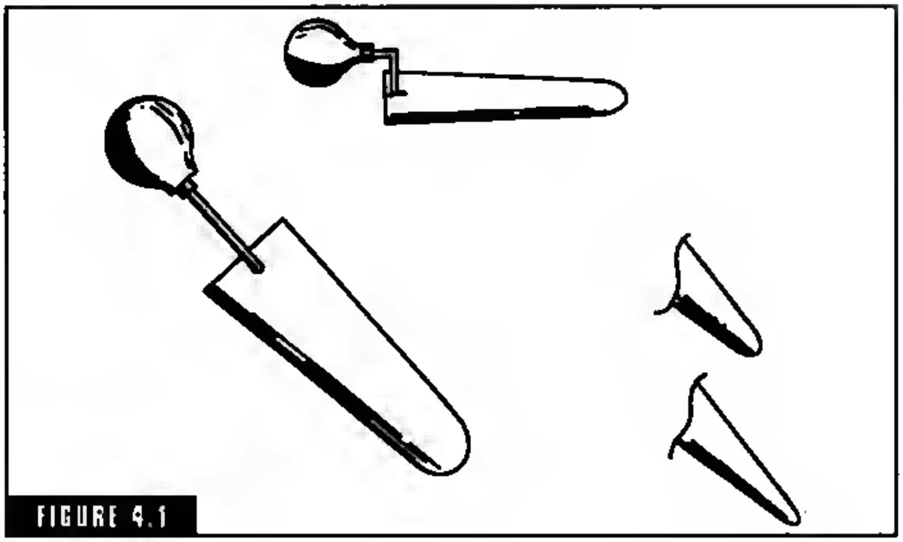

FIGURE 4.1

Molder's trowels.

of tha rounded blada. The hendle teng comes up straight from the blede ebout 2 inchas, then is bent parallal to tha blada to racaiva tha round woodan handla. Tha 2-inch risa gives you knuckle room whan trowaling on a large flat surfaca. Tha only difference between a #1 trowel and a #2 is that the #2 finishing trowal has a mora pointad nosa (Figura 4.1).

Finishing Trowel

The finishing trowal is used to sleek down e surfece, to repeir e surfece, or cut ewey the sand around the cope of a snap flask.

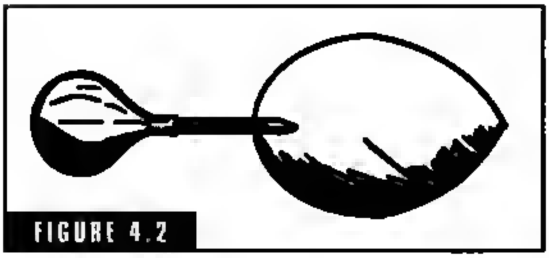

FIGURE 4.2

Heart trowel.

Heart Trowel

The heart trowel is a handy little trowel for general molding and, es its name implies, has a heart-shaped blade. They run in size from 2 inches wide to 3 inches wide in ¼-inch steps (Figure 4.2).

Core Maker's Trowel

The core maker's trowel is much lika a finishing trowel except that the blada

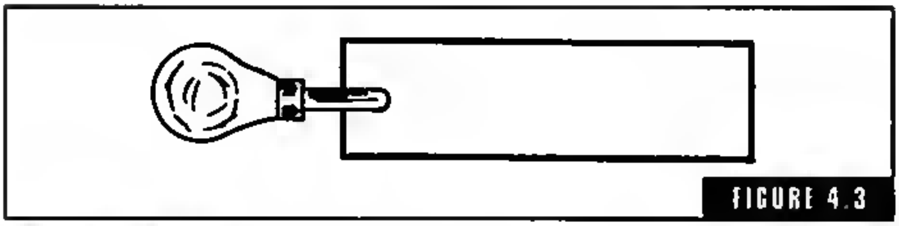

FIGURE 4.3

Core maker's trowel.

edges are parellel elong its entire length and the nose is perfectly square. Core maker's trowels come in widths from 1 to 2 incbes, in ¼ inch steps, and blede lengths of 4½ to 7 incbes, in ½ incb steps. Tbis trowel is used to strike off core boxes and, beceuse it is parallel and square ended, e core can be eesily trimmed or repeired and the sides can ba squared up (Figure 4.3).

Brushes and Swabs

Tbe most popular type of brush for general bencb work and light floor work is the block brusb. It is 1¼ incbes wide and 9 incbes long with four rows of bristles. Its mein use is to brush off the pettern, the metchplete, the bencb, and sometimes the molder bimself.

Camel Hair Swab

A round camel beir brusb (sweb) is used to epply wet mold wesh and core wesb or blacking to e mold or core prior to drying. Most molders carry two sizes—one ¾ incbes in diameter and one ¼ inches in diameter (Figure 4.4).

Flax Swab

Also called e *horse tail*, the flax sweb is used to swab the sand around tha pattern et the junction of the pettern and sand. To dampen this sand to prevent it from breaking eway when the pattern is rapped and lifted from the sand, it is dampened by dipping it into e pail of weter and shaking

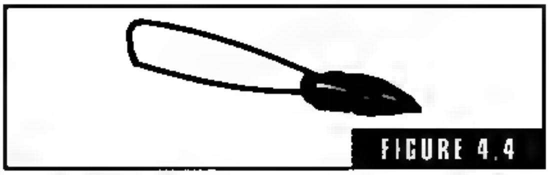

FIGURE 4.4

Camel's hair swab.

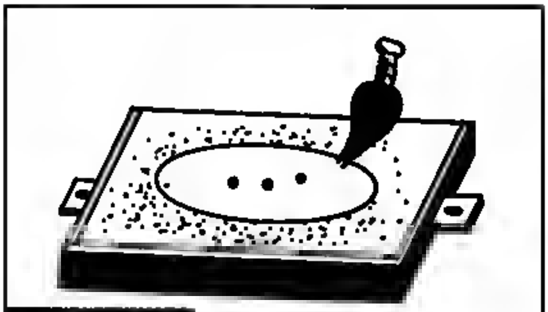

FIGURE 4.5

Use of flax swab.

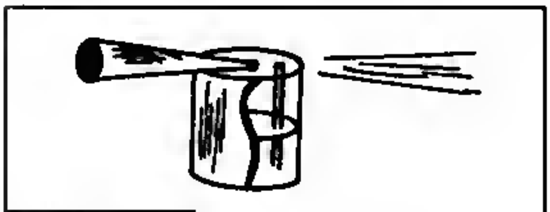

FIGURE 4.6

Motder's blow can.

it out well. It is used on floor work where the pattern presents e fair-sized perimeter (Figure 4.5).

Tbe sweb is elso used by some molders to epply wet mold wash or hlacking to a mold surfece; bowever, this requires greet dexterity.

Blow Can

The blow can is a simple mouth sprey used to apply liquid mold coats and washes to molds and cores, or with weter to dampen e large aree. It can also be operated with the air bose like the sucker (Figure 4.6).

Bulb Sponge

The bulb sponge consists of e rubber bulh with a hollow hrass stem termineting in e soft brusb. Tbe stem is pulled out and the hulh filled ebout three-fourths full of weter. The stem is then replaced. The hulb sponge is used to sweh around the pettern prior to drawing it—the same es the flax sweb is used for floor molding. The bulb is gently squeezed to keep the brush wet while swebbing (Figure 4.7).

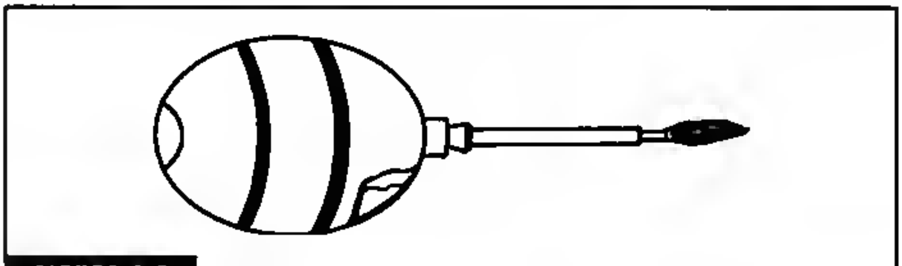

FIGURE 4.7

Bulb sponge.

Sprues and Cutters

You can turn sprues or purchase them in various diameters and use them to form sprue and pouring basins in sand molds. In time you will wind up with e wide selection (Figure 4.8).

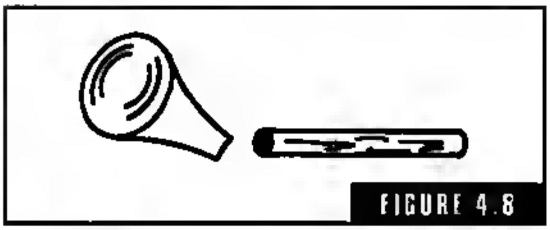

FIGURE 4.8

Wood sprues.

Tubular Sprue Cutters

Tubular sprue cutters are tepered steel or brass tubes used to cut sprue boles in the cope belf of e sand mold. They are sold in sizes from ¼ to 1¼ inches in diameter. All are 6 incbes long (Figure 4.9).

FIGURE 4.9

Tubular sprue cutter.

Gate Cutter

Tbe best gete cutter is mede from e section of e Prince Albert tobecco can or can of similar size (Figure 4.10).

To cut e gete or runner in green sand, the teb is beld between the thumb and first finger and the gete or runner is cut just es you would cut e groove or channel in wood with e gouge. The width is controlled by bending the cutter's sides in and out. The depth is controlled by the operetor.

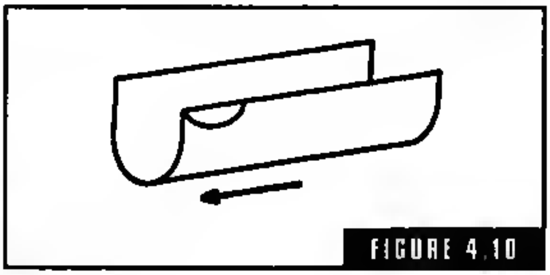

FIGURE 4.10

Gate cutter.

Ramming and Rapping Tools

Various tools are used by the metalcester for the ramming and repping operetions involved during molding.

Bench Rammer

A bencb rammer (Figure 4.11) can be mede of oiled meple. You can buy one or turn one on e lethe. Use e bandsew to cut the wedge-sbeped peen end.

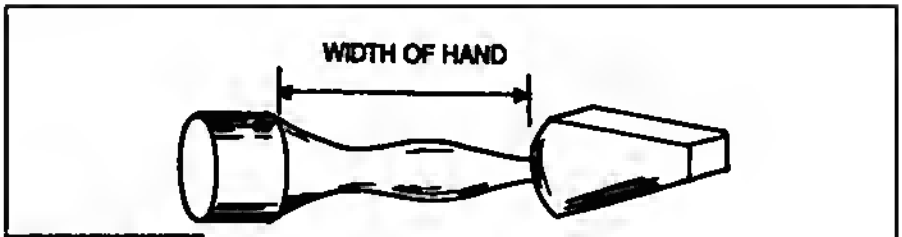

FIGURE 4.11

Bench rammer.

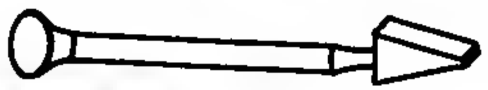

FIGURE 4.12

Floor rammer.

FIGURE 4.13

Rapping bar and rapper.

The butt end is used to actually ram the sand into the flask around the pattern. The peen and is used to *peen* or ram the sand tigbtly around the inside perimeter of the flask to prevent tha copa or drag mold from falling out wben either half is moved, rolled over, or lifted.

Floor Rammer

The floor rammer has the same purpose and design as a hanch rammer except the butt and peen ends are made of cast iron and attached to each end of a piece of pipe or hickory handle. The average length is 42 inches (Figure 4.12).

Rapping Bar and Rapper

Tha rapping bar consists of a piece of hrass or steel (cold roll) rod which is machined or ground to a tapered point. The rapper is made of steel or hrass and is shapad exactly lika tha frama of a slingsbot (Figura 4.13).

The purpose of these tools is to rap or shake the pattern loose from the sand mold in order to draw it easily from the sand. When you shake the pattern in all directions, it drives the sand slightly away from the pattern. The resulting mold cavity will actually be a hit larger than the pattern. The pattern sbould only be rapped enough to free it from the sand. You will be able to see when it is loose all around by the movement of the pattern. Over-rapping will distort the mold cavity, which may or may not matter depending on how close you wish the casting to hold a tolerance (Figure 4.14).

The operetion is quite simple. The har point of the rapping bar is pressed down into a dimple in the parting face of the pettern with the left hand. The repper is used to strike the har with the inner feces of the yoke.

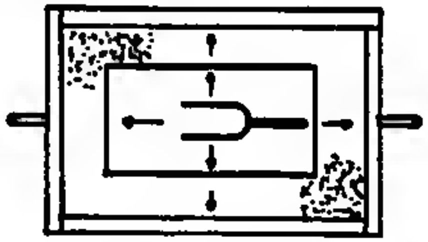

FIGURE 4.14

Rapping.

Hand Riddles

You need two 18-inch diameter riddles—one with #4 mesh and one with #8 mesh gelvanized iron screen. The #4 mesh will he used for general bench work and floor molding. It will riddle the first sand over the pettern hefore filling the mold with the shovel and ramming. The #8 mesh serves the same purpose but also applies fine fecing sand to special johs such es plaques or greve markers (Figure 4.15).

FIGURE 4.15

Hand riddler.

Bellows

In general there are two types of bellows. One has e short snout and it is called e *bench bellow.* The other one has e long snout and is called e *floor bellow.* The theory is thet e molder can wreck e hench mold when hlowing it out with e long snout floor hellow hy hitting the sand with the snout. This is true due to the different stance and angle when hlowing e mold hench high, or on the ground. With care one only needs e 9- or 10-inch floor bellow to hlow out cope and dreg molds, sprue hole, and getes (Figure 4.16).

Strike Off Bar

Eech time e mold is rammed up the sand must he struck off level with the flesk cope and drag. The bar simply consists of e metal or hardwood straightedge of sufficient length (Figure 4.17).

Rawhide Mallet

The mallet is a minimum weight of 21 ounces and is used to rap petterns or draw pikes to loosen the pattern from the sand so it can he smoothly withdrawn from the mold without damage to the mold or pettern.

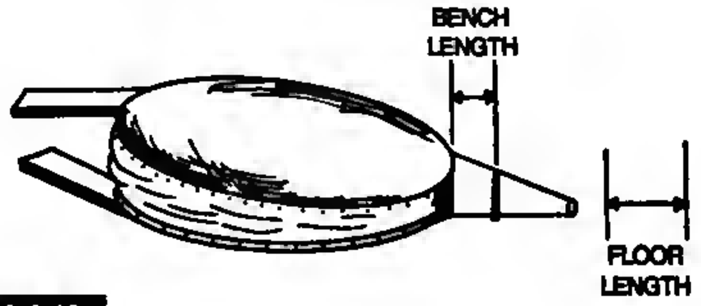

FIGURE 4.16

Molder's bellows.

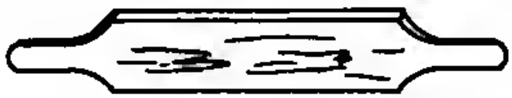

FIGURE 4.17

Strike-off tool.

Miscellaneous Tools

There are several other tools necessary for the molder to successfully complete his metalcasting operetions.

Draw Pins, Screws, and Hooks

These items are used to remove or drew the pattern from the mold. The drew pin is driven into the wooden pettern and used to lift it out as e handle. On e short small pettern one pin in the center will do. If the pattern is long, use one on eech end for e two-hand straight lift. The draw hook is used the same wey. The drew screw is screwed into the pattern for a hetter purchase on heavier patterns, and prevents the pettern from eccidentally coming loose premeturely and falling, damaging the mold, pettern, or hoth. In large petterns, pletes, which heve e tepped hole into which e drew pin with e metching thread is screwed for lifting hy hand or with e sling from e crane, are let into the pettern et its parting fece. Two or more are usuelly used (Figure 4.18).

Loose metal petterns are drilled and tapped to receive a drew pin.

Sucker

Tha suckar is not a purchased tool hut one made hy the molder. It consists of two pieces of tuhing and a tee of coppar or iron (Figura 4.19).

Tha sucker is used to clean out deep pockets in molds where tha hallows and liftar fail, or in cases whera the pockat or slot is so dirty that using a lifter would taka too long. It is also usaful whera it is impossihle to sae to use a liftar. The operation is vary simpla. You simply hlow through tha alhow with an air hosa. This creates a vacuum in the long langth, which givas you in affact a vacuum claanar with a long skinny snout. Now stick the long and down to where tha prohlem is and hlow through tha alhow. Suckars will lift out small steel shot, a match stick, or matarial which cannot ha wetted such as parting powder or silica sand (Figura 4.20).

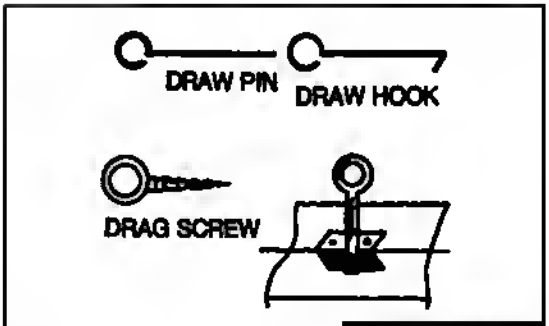

FIGURE 4.18

Draw pins and draw plate.

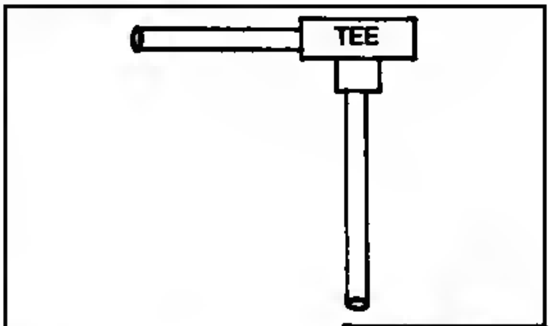

FIGURE 4.19

Sucker.

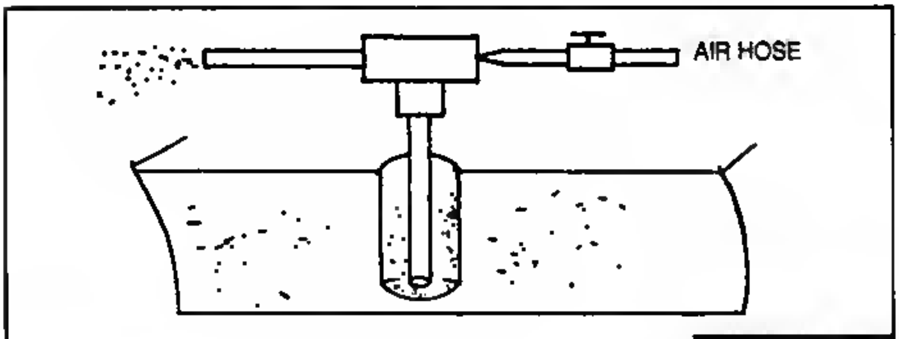

FIGURE 4.20

Operation of sucker.

FIGURE 4.21

Bench lifter.

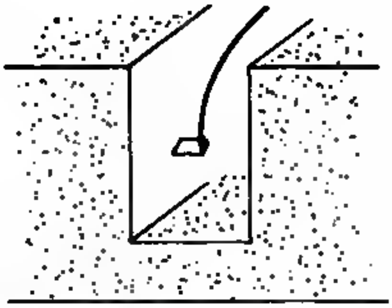

FIGURE 4.22

Using the bench lifter.

A word of warning—watch which direction you have the discharge end of your sucker pointed when sucking out a mold. You could accidentally blow sand in someone's eyes.

Bench Lifter

The hench lifter is a simple steel tool with a right-angled square foot on one end of a flat hent hlade (Figure 4.21).

This tool's higgest use is to repair sand molds and lift out any tramp or loose sand that might have fallen into a pocket (Figure 4.22).

To remove dirt from a pocket that will not hlow out with the hellows, you simply spit on the heel of the lifter and reach down and use the moistened end to pick it up. Then wipe off the heel and go back and slick the spot down a bit.

Lifters come in all sizes from a hench lifter ¼ inch wide hy 6 inches long to floor lifters 1 inch wide and 20 inches long. All have the same use. Many molders make their own lifters to suit the class of work they generally do.

Slick and Oval Spoon

The slick and oval spoon is a must for all molders. Again the size needed is determined hy the work involved. Most molders have at least four sizes from one ¼ inch wide to one 2 inches wide. This tool is cared a *double ender* in the trade. One end is a slick similar to a heart trowel blade but more oval shaped. The opposite end is spoon shaped. The outside or working surface is convex like the hack of a spoon. Its inner face is concave. This face is never used and therefore is usually not finished smooth. When new it is painted hlack. Both faces of the slick hlade are highly polished (Figure 4.23).

The douhle ender is a general use molding tool used for slicking flat or concave surfaces, for opening-up sprues, etc.

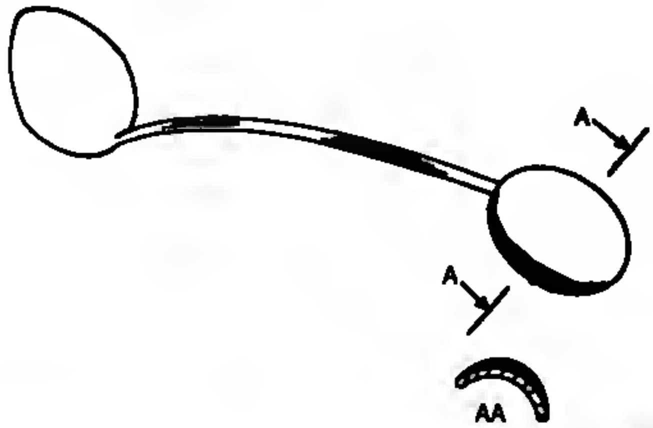

FIGURE 4.23

Slick and oval.

Dust Bags

Two dust begs are needed by the molder—one 5 × 9 incbes for parting powder and ona 7 × 11 inches for graphite. These bags can ha purchased from supply bouses, but most give them away. You can, as I do, use an old sock (with no holes) for hoth parting and blecking. Tbe parting beg is used to sbake parting on the pettern and parting line of the mold feces. Tbe blecking beg is used to dust blecking on a mold surface prior to slaeking.

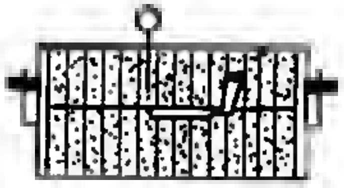

FIGURE 4.24

Vent wire.

Vent Wire

Vent wire is simply a slender pointed wire with a loop et its top used to punch vent boles in the cope and drag of e sand mold. It provides eesy access for steam and gases to the outside during the pouring of the casting. The vanting is done prior to the pettern ramoval. Tbe vent wire is pusbed down into the sand to close proximity of the pattern. Tbe first and second finger straddles the wire eacb time it is withdrewn es e guide (Figure 4.24).

Flasks

Sand molds used in metelcesting are mede in wooden frames called *flasks*. They have no resemblance at all to the glass or metal liquid container most people think of when they see or hear the word flesk.

They ectuelly are open wooden frames that can be held together with pins and guides. They are separated during the mold preparetion process and placed back together for pouring the mold without losing the originel register. A flesk with good pins and guides will close beck together in the exect same place every time. This is essentiel to evoid shifts in the mold cevity, with e resulting defect.

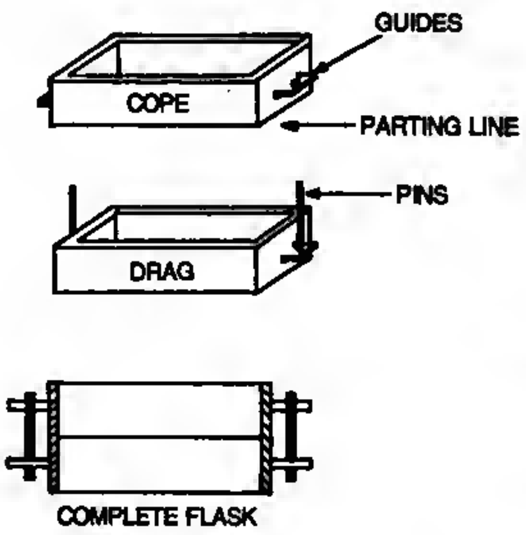

FIGURE 4.25

Basic flask assembly.

Basic Flask

The top frame of the flesk is called the *cope* and the bottom frame is called the *drag* (Figure 4.25).

In some molding operetions you need one or more sections between the cope and the drag. These sections are celled *cheeks* (Figure 4.26).

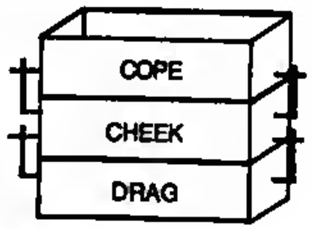

FIGURE 4.26

Flask with cheek.

The pins and guides thet are used to bold the sections together can be purchesed in e wide variety of types and configurations—round and half round, double round, and vee shaped. Single, double, or triple vee shepes are peckaged together with matching guides. Both pins and guides beve ettached mounting plates by whicb they can be bolted, screwed, or welded to the halves wbicb make up a complete flesk set (Figure 4.27).

Homemade Wood Flask

In bobby or small sbops you will find wood flesks with simple wood guides and pins. Although they work for a while they soon loosen or burn up from spilled metal. Only resort to this type for a one-time quick job for whicb you must build e quick flask to fit (Figure 4.28).

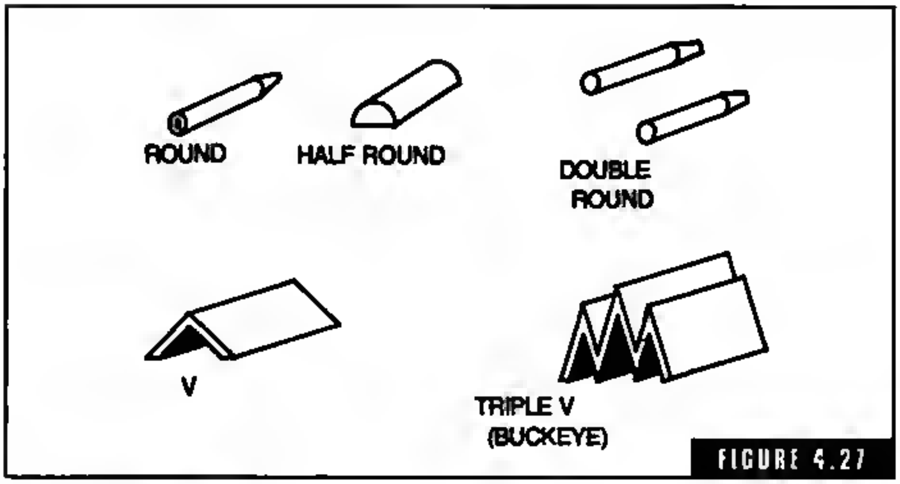

FIGURE 4.27

Alignment pin types.

Floor Flasks

There are some flasks that are too large to be handled on the bencb. Tbese can be of wood or metel. The wood flasks are constructed in sucb e manner thet the long sides provide the lifting bandles for two-man lifting and handling.

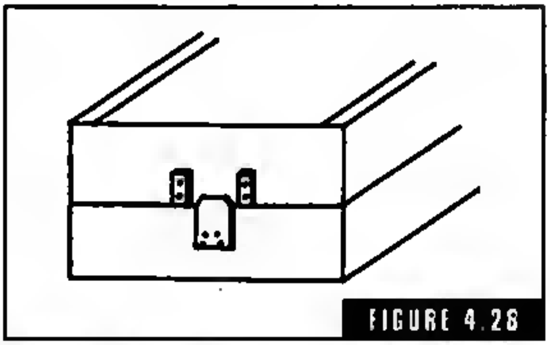

FIGURE 4.28

Wood pins and guides.

Floor flasks, unlike bencb flasks, need support when a certain size is reeched: usually, et 18 × 18 incbes, support rods are put in the cope. These support members are called *bars*. These bars belp support the weight of the sand in the cope to prevent it from dropping out. Bars are required in the drag balf of the flesk only when it is necessary to roll the job over and lift the drag instead of the cope. In sucb cases they are called *grids* (Figure 4.29).

The bars do not come all the wey to the parting but clear the parting and portion of the pattern thet is in the cope by an minimum of ½ incb. Tbese bars, in many ceses, beve to be contoured to conform to the portion of the pettern thet is in the cope (Figure 4.30).

In all cases the bars are brought to a dull point along their lower edge to make it possible to tuck and ram the sand firmly under them (Figure 4.31).

Tbe inside surfeces of both the flask and the bars in the cope section are often covered with large-beaded roofing neils with the bead

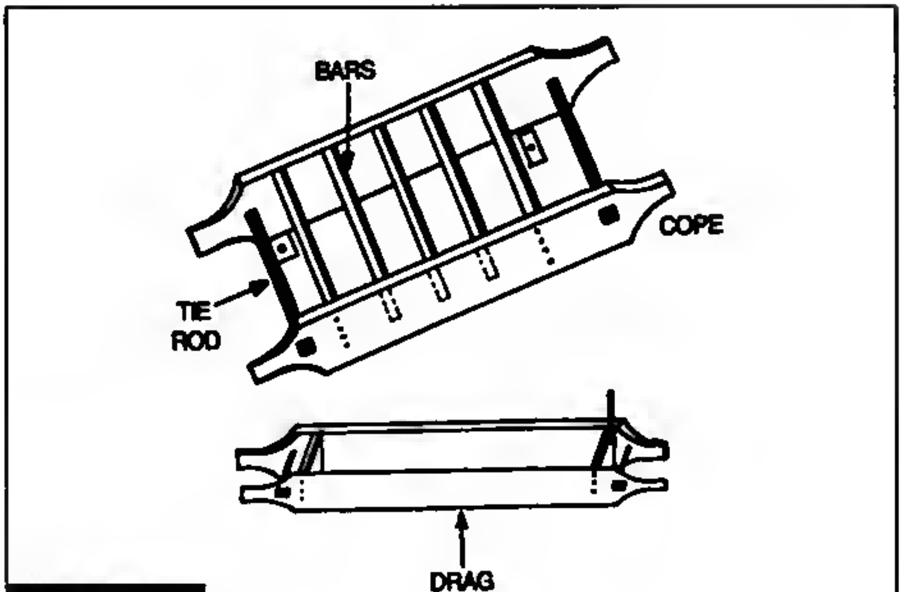

FIGURE 4.29

Wood floor flask.

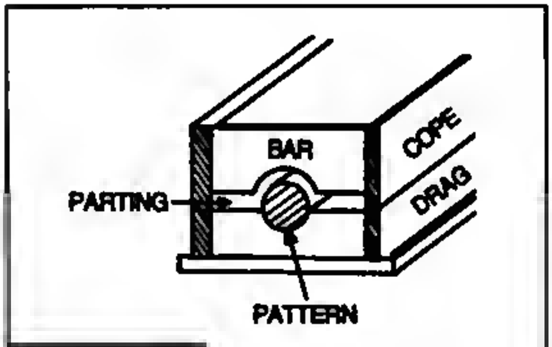

FIGURE 4.30

Contoured cope bar.

projecting ⅛ to ¼ inch. Tbis gives the entire inner surfece an excellent tooth and e good purcbese on the sand.

Of course the floor flesk, like all others, must be provided with suiteble pins and guides on both ends.

Small floor flesks up to 30 × 30 inches with e cope and drag depth of from 5 to 8 incbes can be made of 1-inch lumber. From 32 × 32 incbes to 48 × 48 inches with 5-inch to 10-inch cope and drag, use 2-inch lumber. From 50 × 50 incbes to 62 × 63 inches with 6-inch to 19-inch cope and drag, use 2½-inch lumber. From there up to e flask that measures e maximum of 85 × 85 inches with a cope and drag depth of 7 to 30 inches, use 3-incb lumber. The bars sbould be made of the same thickness of lumber as the flask. The number of bars required is generally determined so that you have a maximum of 6 inches of sand between them.

If your flesk is extremely wide, you might need e cross bar between the bars. Tbis bar is called e *chuck* (Figure 4.32).

When you get to e flask larger than 85 × 85 inches you should move to welded steel.

Where the type of work permits, the floor flask can be fitted with roll-off hinges. These binges allow the flask to he opened like e book. The pettern is ra-moved and the mold is closed. This operation is completed without lifting the cope (Figure 4.33).

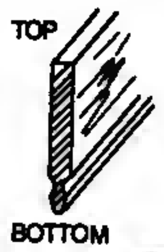

FIGURE 4.31

Contoured bar.

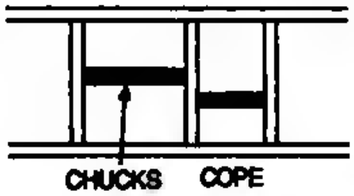

FIGURE 4.32

Cope chucks.

Large Steel Floor Flasks

Large steel floor flasks are more often equipped with female guides on both cope and dreg balves with loose pins used for molding and closing. Some have single hole guides, some heve douhle hole guides (Figure 4.34).

Steel flasks can be purchased in all sizes with any size cope and drag depth, or any comhinetion of different cope and dreg depths and any type of pin and guide arrangement you desire.

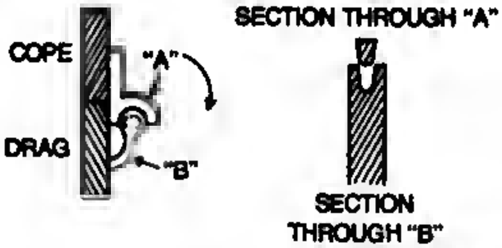

FIGURE 4.33

Roll-off hinge and guide.

Snap Flask

A snap flask is usually mede of cherry wood. After the mold is mede, the flask can be removed by opening the flask and lifting it off the mold, leeving the mold as e block of sand on the bottom board (Figure 4.35).

In corner A, both the cope and drag heve e hinge and in corner B, e cam locking device. In operation the cope and the drag locks are closed tight and the mold is mede in the usual manner. When finished, the locks are opened and the flask is opened and removed from the mold. A typical snap flask hinge and lock is sbown in Figure 4.36.

Tbe big edvantege of the snep flask is that you need only one flask to make as many molds e day as you wish. With rigid flasks you need es many flasks es the number of molds you wisb to put up et e time.

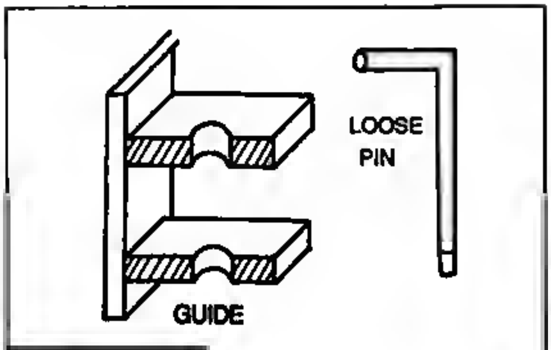

FIGURE 4.34
Loose pin and guide.

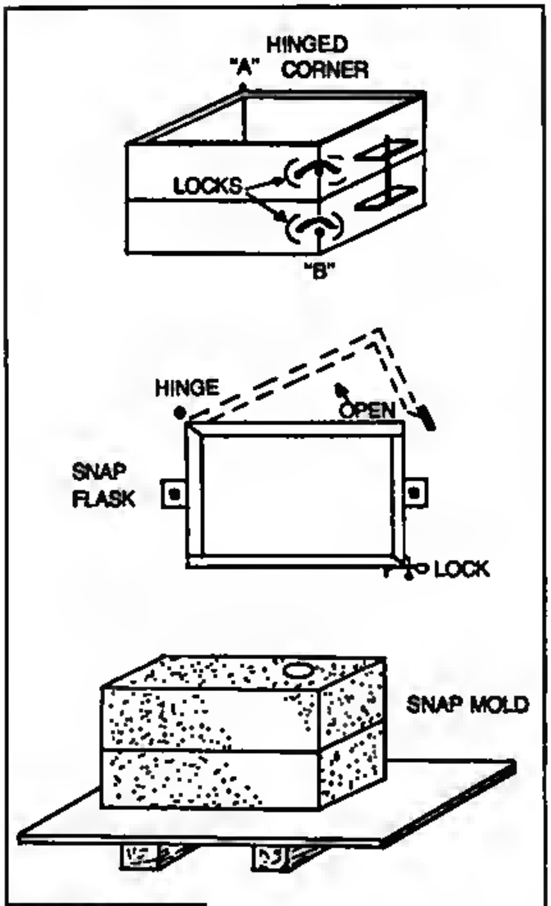

FIGURE 4.35
Snap flask.

Other Types of Flasks

There are two other types of flasks that are removed from the mold. One is called a *tapered slip flask*. In this type of flask there is a strip of metal on the parting face of the cope thet prevents the cope from dropping out while molding, which it would do without the strip, due to the taper on the cope's inner surface. After the mold is mede end closed, this strip is retracted by a cam lever. When the strip is retrected the tapered flesk is easily removed by simply lifting it from the mold (Figure 4.37).

The other type is called e *pop-off flask*. In this type of flask, both corners thet cope and drag diagonally across from one another are clamped by e cam locking device. Wben the mold is completed the cam is released and the spring-loeded corners pop epart just enough to release the sand mold. These are quite popular and can be hed in enormous sizes for floor and crene work es wcll as smell bench sizes.

Jacket

A *jacket* is e wood or metal frame which is placed around a mold made in a snap flask during pouring to support the mold and prevent a run out between the cope and drag.

The common prectice is to have as many jackets for each size snap mold as can be poured et one time. When the molds heve solidified sufficiently the jackets are removed and pleced on the next set of molds to be poured. These are called *jumping jackets*. Jackets must be carefully placed on the molds so as not to shift the cope and drag. The jackets must be kept in good shape and fit the molds like a glove. A tapered snap flask and tepered jackets work best due to the taper (Figure 4.38).

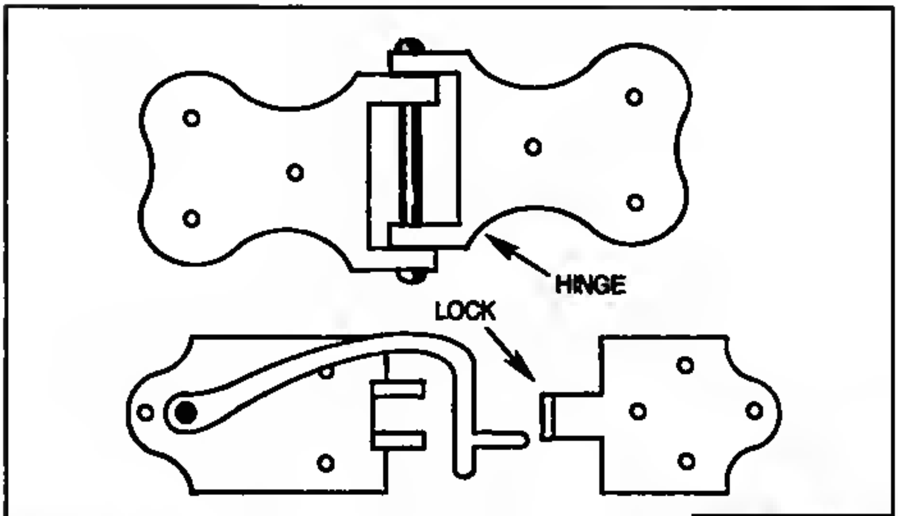

FIGURE 4.36

Snap hardware.

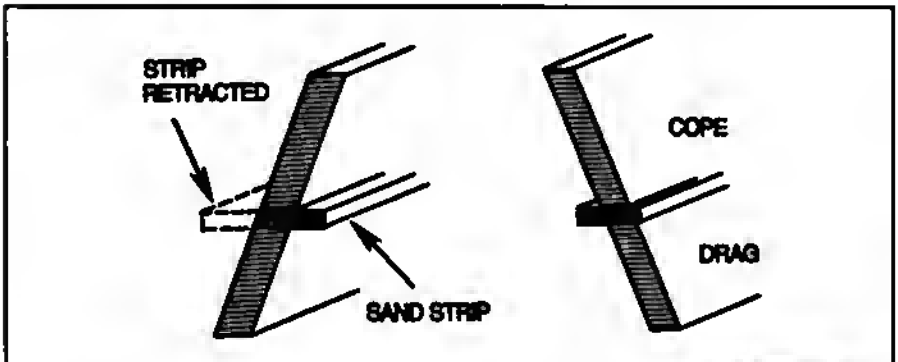

FIGURE 4.37

Tapered slip flask.

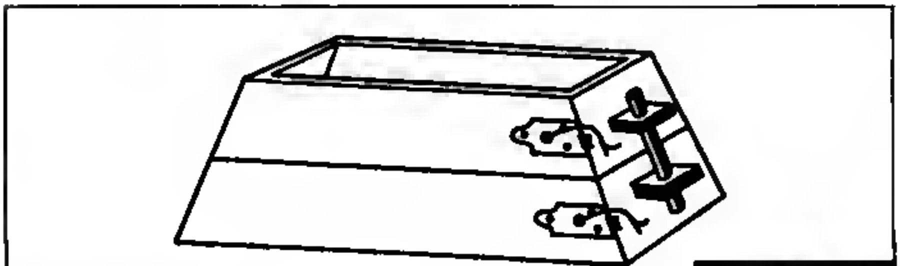

FIGURE 4.38

Tapered snap flask.

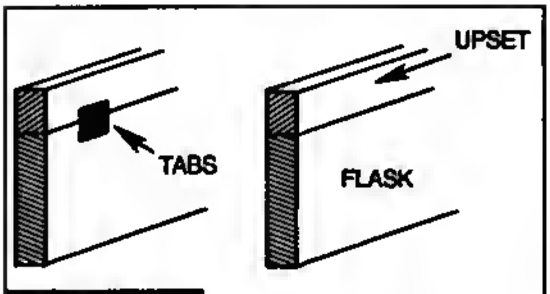

FIGURE 4.39

Upset.

Upset

When you need a taller cope section or drag section than the flask on hand, use a frame of the required additional depth. The inside of the frame is provided with four or more metal strips or tabs which fit down into the flask to hold it in place during molding. These strips or bands (they may be sheet iron bands) are called *upsets*. The term *to upset* a cope or drag means to add depth to it (Figure 4.39).

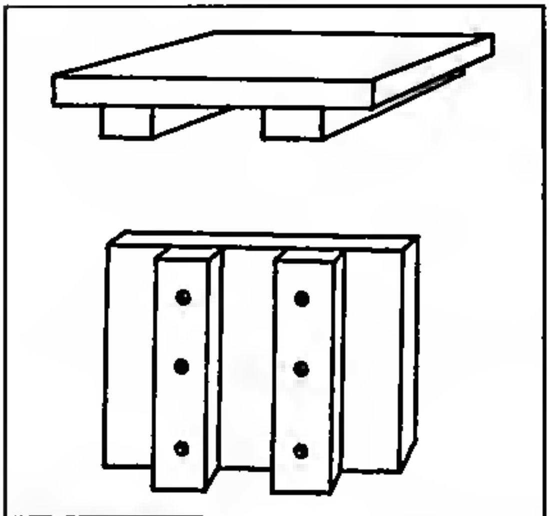

FIGURE 4.40

Molding board.

Boards

All boards for molding should be smooth. The pattern and flask rest on such boards when you start to make the mold.

Molding Board

The molding board is a smooth board on which to rest the pattern and flask when starting to make a mold. The board should be as large as the outside of the flask and stiff enough to support the sand and pattern without springing when the sand is rammed. One is needed for each size of flask. Suitable cleats are nailed to the underside of the board. Their purpose is to stiffen the board and to raise it from the bench or floor to allow you to get your fingers under the board to roll over the mold (Figure 4.40).

Bottom Board

The bottom board is used to support the sand mold until the mold is poured. It is constructed like the molding board, but it need not be smooth, only level and stiff. Bottom boards from 10 × 16 inches to 18 × 30 inches should be made of 1-inch thick lumber with two cleats made of 2 × 3-inch stock. Bottom boards 48 × 30 inches use 1½-inch thick lumber with three cleats made of 3 × 3-inch stock. Bottom boards

50 to 80 incbes use 2-inch thick lumber with four to five cleats mede of 3 × 4-inch stock.

Clamps and Weights

Floor molds are always clamped to pour. Sometimes they are weighted, sometimes not, but they are alweys clamped.

Floor Mold Clamps

There are two basic types of clamps used (Figure 4.41).

The C-clamp is cest iron or square steel stock. In operetion the bottom foot is pleced under the bottom board and e wooden or steel wedge is tapped between the top foot and the top of the flask side (Figure 4.42).

A better prectice is to plece two wedges between the clamp foot and flask by band, then tighten them with e small pincb bar. Driving them too tightly jolts the mold and could ceuse internal damege, such as e drop (Figure 4.43).

Tbe jack clamp is the preferred, but most expensive clamp. Its operation is simple. The foot is placed under the bottom board and the clamping foot is slid down egainst the cope flesk. A bar is pleced in the cam lever and pushed down until the clamp is snug and tight.

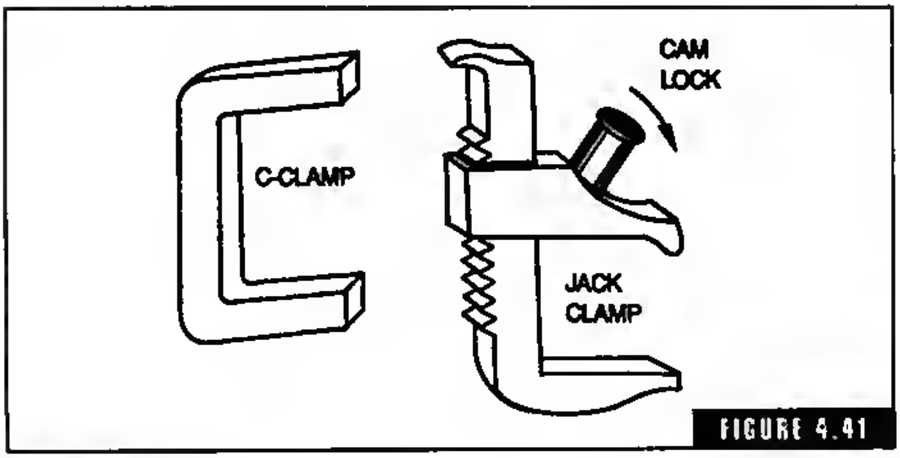

FIGURE 4.41

Floor mold clamps.

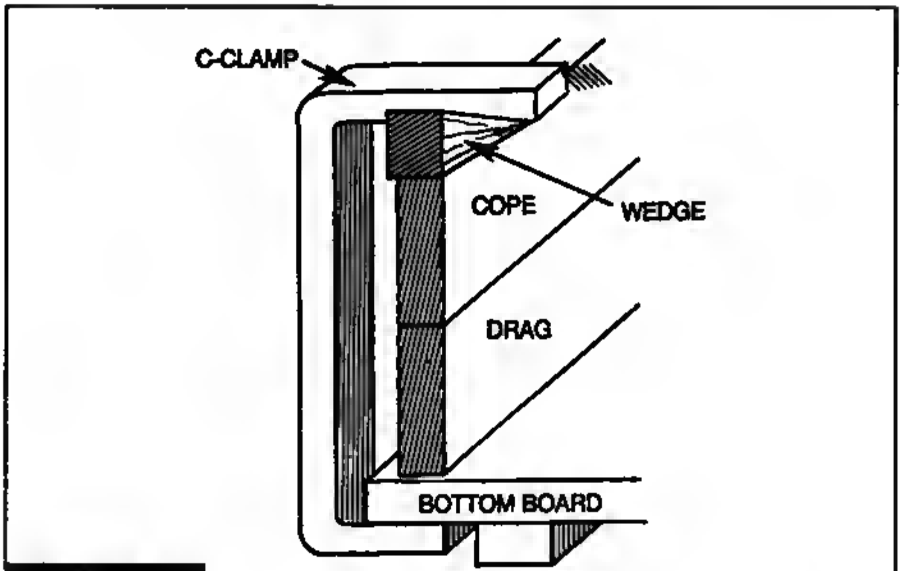

FIGURE 4.42

The use of C-clamps.

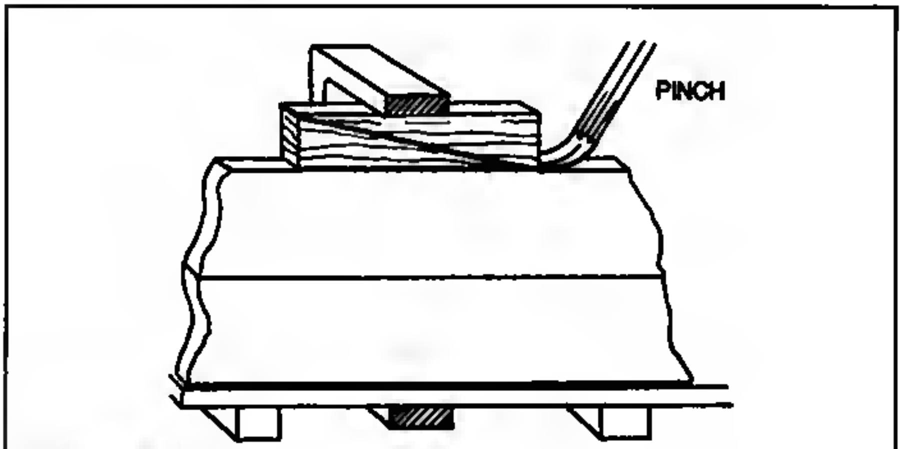

FIGURE 4.43

Double wedged C-clamps.

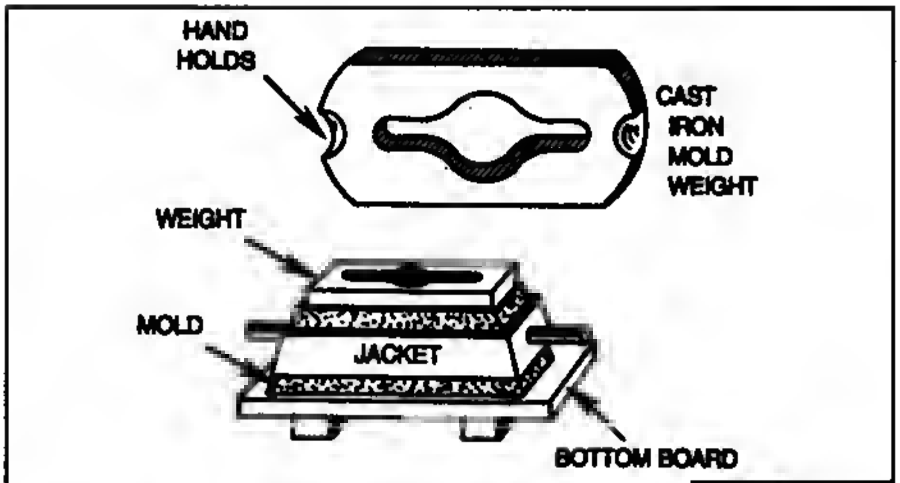

FIGURE 4.44

Typical mold weight.

Mold Weights

All snep flask work is weighted hefore molding. In most cases all thet is needed is e standard snap weight. It is usually cast to suit your own snep sizes (Figure 4.44).

The snep flask mold weights are made from 1¼ to 2 inches thick cast iron and weigh from 35 to 50 pounds for e 12 × 16-inch mold. The rounded cross-shaped opening through the weight is to eccommodete pouring the metal into the mold. The weights are alweys set so thet the pouring hasin is free to easily see and pour, not too close to the weight.

In some cases two or more weights are used per mold and are stecked.

Another type of mold weight which I fevor for snap and small rigid flask hench work is the *sod iron* type of weight. They look like the old-time irons heeted on the stove for pressing clothes, only heevier (Figure 4.45).

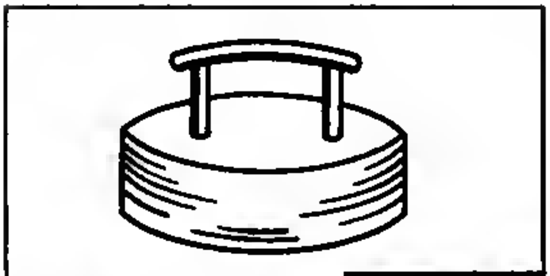

FIGURE 4.45

Sad iron weight.

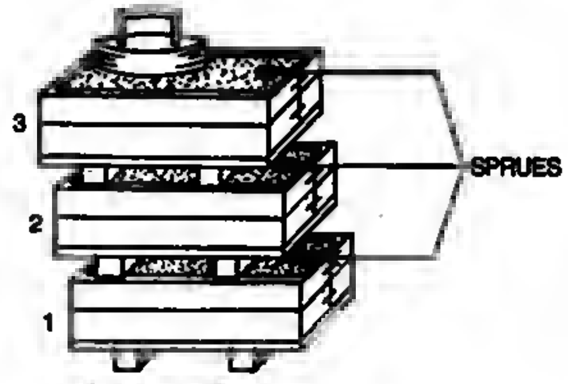

FIGURE 4.46

Stacked molds.

Another method used to weight bench molds in rigid full flesks, whether wood or metal, is to steck the molds three high, similar to steps. Tbis method puts weight only on the top mold. Tbis prectice was quite common in e greet many foundries and is still used todey in bome casting sbops (Figure 4.46).

Tbe lifting or buoyant force on the cope is the product of the horizontel aree of the cavity in the cope, the beight of the bead of metel ebove this aree, and the density of the metel. This lifting force on the cope bas to be dealt with by the metalcaster. If the force is greeter than the weight of the cope, the cope will be lifted by this force when the mold is poured. It will run out et the joint, resulting in e lost cesting. In order to determine bow mucb weight bes to be pleced on the cope to prevent e lift of the cope, multiply the area of the surfece of the metal pressing egainst the cope by the depth of the cope ebove the casting and the product by 0.26 for iron, 0.30 for brass, and 0.09 for aluminum. Tbese figures represent the weight in pounds of 1 cubic incb of iron, brass, or aluminum, respectively.

If you are casting a flet plete 12 × 12 incbes, the surface aree egeinst the cope will be 144 square inches. If this would be molded in e flesk whicb measured 18 × 18 incbes with e 5-inch cope and the cesting metal would be red brass, we'd have 144 × 5 incbes (the beight of the cope × 0.30 (the weight of 1 cubic inch of bress). You'd wind up with e lifting force of 216 pounds. One cubic incb of rammed molding sand weighs 0.06 pounds. With that factor, the cope weigbt would be 18 ×

18 × 5 inches × 0.06 or 97.2 pounds. If you subtract the cope weight from the lifting force—216 pounds minus 97.2 pounds—you are still short by about 119 pounds. This would be the weight you'd have to add to the cope to prevent it from lifting, with no safety factor. With a 20 percent safety factor, add 24 more pounds. You should put 150 pounds on the cope.

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CHAPTER 5

Metal Melting Devices

Nonfarrous matals are melted in numarous typas of furnaces. The crucibla furnaca is the most common and lowest in initial cost.

Crucible Furnaces

The furnace is essentially a refractory-lined cylinder with a refractory cover, equipped with a hurnar and blowar (Figura 5.1) for tha intense combustion of oil or gas. The metal is melted in a crucibla (pot) made of clay and graphita, or silica carbide, which is placed in the furnaca. Whan tha malting is complata, the furnaca is turned off, the furnace cover is opened, and the crucibla removad with tongs and placed in a pouring shank. Then the liquid metal is poured into prepared molds.

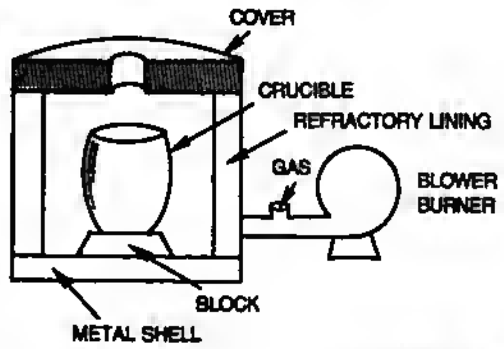

FIGURE 5.1

Crucible furnace.

A crucible furnace can be made from an old metal drum or metal garbage can, a few pipe fittings, the blower from an old vacuum cleaner, and 30 or 40 dollars worth of castabla rafractory material. The refractory suppliers can also furnisb you with complete advice on what to buy for your particular purpose, along with tips on how to handle the material. Crucibles come in sizes from as small as your thumb to a number 400, which will bold 1200 pounds of moltan bronze.

Homamada malting furnaces are simpla to construct, and are fun to build and operate. A furnaca for a No. 20 crucibla, which bas a single pour capacity of 60 pounds for bronze, or 20 pounds for aluminum, would be considered averaga in size.

By weight, cruciblas will bold threa timas as much bronza as aluminum. Always allow soma claarance below the top of the crucible for safaty—it is dangerous to melt a brimming potful.

Let's assuma, for this discussion, that you hava cbosan a No. 20 crucible: 10¼ incbes high, $7\frac{13}{16}$ inches across the top and bottom, and 8½ inchas at its *bilge*, or widast point (its sbape resembles that of a barrel). This crucible requires a basa in the form of a truncatad cona 6 incbas across tha top, 7 inches across the bottom and 5 inches bigh. Now we have 15 inches of baight and 8 incbas in diamater to go into tha furnaca.

Thare must ba sufficiant distanca between the crucibla and the furnace lining for correct combustion, and for room to fit opan tongs around tha crucibla. Also, enough spaca between tha furnace bottom and tha covars is needed for correct combustion and exhaust through tha cover opening. A good general rule is to allow 2½ to 3 inchas of clearance between the furnaca wall and tha bilge. Leave 3 inches batwaan tha top of tha crucibla and the cover and abova tha furnaca bottom. In general, the lining should be a minimum of 4 inches thick to insura good insulation.

With this we need a sball for our furnaca 22½ inches (inside diameter) by 22¼ incbes bigb with a covar band (Figure 5.2) 22½ (inside diametar) × 4 incbes in baight. A safety hola directly in tha front of tha furnaca, flusb with the bottom and 3 incbes square, is needed. Should tha crucible break, the metal will run out of tha furnace through the hole.

Without a safety hole, metal could run into the burner pipe, or simply fill up the bottom of tha furnace and solidify there, leaving you

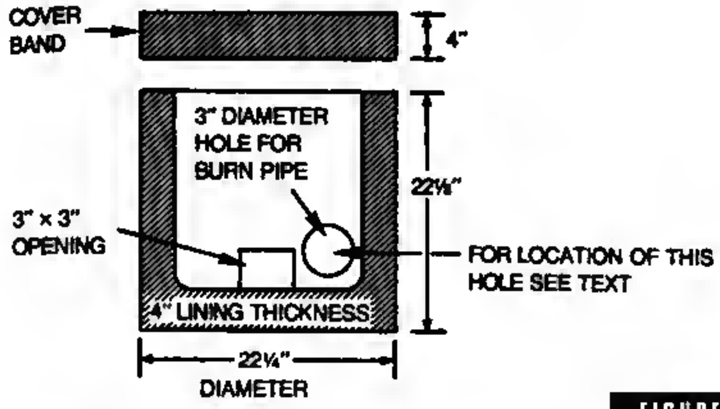

FIGURE 5.2

Furnace dimensions.

with e hunk of metel next to impossible to remove short of tearing everything epart.

The shell is completed by making e 3-inch hole 6 inches ebove the bottom of the shell, e third of the shell's circumference ewey from the safety bole. Tbis is wbere the burner pipe enters. The burner pipe is brought in 2 incbes ebove the refractory lining of the bottom, and off-center from the diameter of the sbell so thet the flame will circle the spece between the crucible and the lining, spiral around the crucible and out of the vent bole; this gives the bighest and most even heat (Figure 5.3).

The cover consists of e metal band formed into a ring 22½ inches in diameter, but tapered slightly (Figure 5.4). Tebs or lifting ears must be riveted on directly ecross from each other on the cover ring. They should be drilled with holes to clear e ½-incb pipe, which will be used to remove the cover.

The cover ring is placed on a smooth floor covered with newspeper in preparation for making the exheust bole.

SAFETY TIPS

Clearance between molten metal and the top lip of the crucible is essential: brimful melts are dangerous.

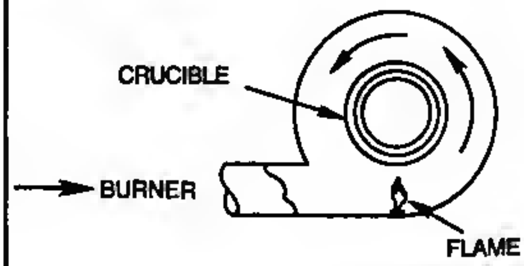

FIGURE 5.3

Heating method.

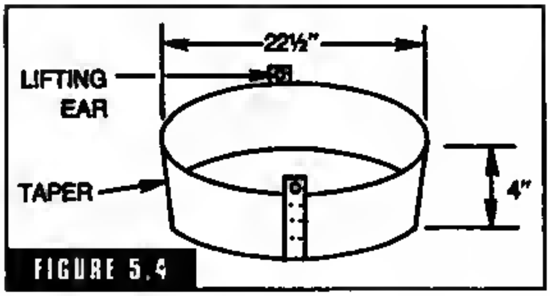

FIGURE 5.4

Cover ring.

Within the center of the cover ring, place a 6-inch tin can or jar as a form for the exhaust vent. The castable refractory material is now mixed according to the manufacturer's directions, tamped firmly in place around the vent form, leveled off smoothly with the top of the ring, and left to set overnight.

Now we are ready to line the furnace body. Place a heavy cardboard sleeve 14½ inches in diameter and long enough to extend slightly above the top of the shell in the center of the furnace—22 or 23 inches tall should do.

Once the sleeve is centered, fill the inside of the sleeve with dry sand to give it added strength. Hold it in place while tamping in the lining all the way to the top. Two plugs will be needed for the furnace shell while the lining is being installed: one to fit through the safety hole and against the cardboard sleeve and another to fit the burner port. Dimensions for the plugs are given in Figure 5.5.

Coat each plug with heavy oil or grease, and fit both into their respective places. Use small wooden wedges to get a snug fit.

With both plugs securely in place, start tamping in the lining, making sure the castable refractory is well compressed. Do not place too

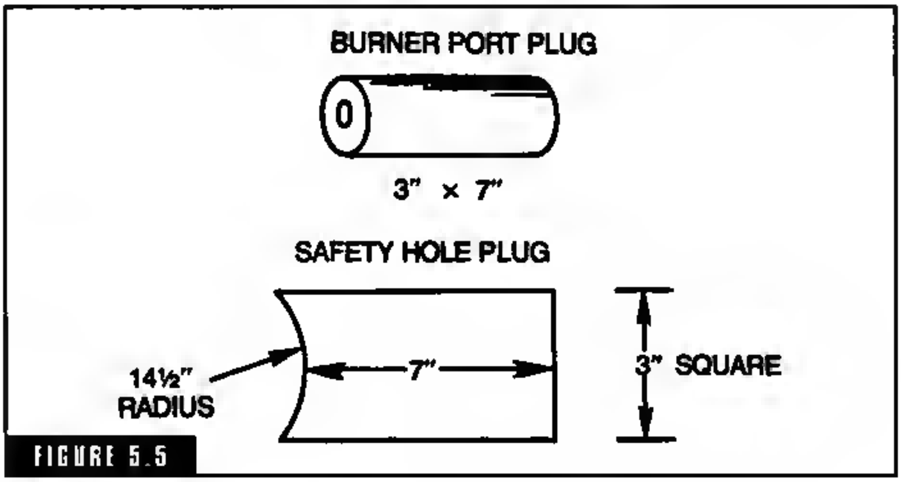

FIGURE 5.5

Hole plugs.

much material between the sleeve and the shell at a time; doing so will produce gaps. When the top of the shell is reached, trowel and smooth the refractory. The furnace is now complete.

Small furnaces, or *coffee-can foundries*, are easily made using a large coffee can as the form for the furnace, lining it with refractory material, and using a propane torch to heat and melt small quantities of aluminum, zinc alloys, and similar low-melting point metals. Generally, this furnace should work well with all metals up to some forms of brass.

Make the furnace with two side ports made from plumbing nipples to let the flame in. Supply a vented lid, and use furnace cement as a refractory material (use a can half the size of the original can to form the center, which is surrounded by refractory cement).

This furnace can melt aluminum on a gas range—although your spouse may not appreciate the concept or the action.

Burners

Now you must have a suitahle burner and a hlower thet will deliver 300 cuhic feet of air per minute.

A blower from an industrial vacuum cleaner will deliver enough air et the right pressure.

The simplest type of ges burner can be mede from e pipe 2 feet long. Heat the pipe red-hot et one end and hammer the end partielly closed—not much over ¼ inch in ell around—so that you are left with an opening 1½ inches wide. Heat the pipe again, 1 foot from the hammered end. Hammer in a neck with an inside diameter 1¼ inches that is 1 inch wide (Figure 5.6). In the hottom of the groove left from this *necking down*, hurn a hole and fit e ½-inch pipe snugly into it. Weld it in plece. You have just mede e nipple for the gas line.

Insert the hurner pipe into the hurner port in the furnece hody, ettach the hlower to the opposite end, connect a stopcock to the nipple, and connect the whole thing to e gas outlet.

The intake of the blower must be provided with a shutter or damper to regulate air going to the burner.

A butterfly valve will fit within the burner pipe. Whether you decide to control the air in the burner pipe or at the blower intake doesn't matter, but it must be constructed in a manner that provides positive action without moving of its own accord.

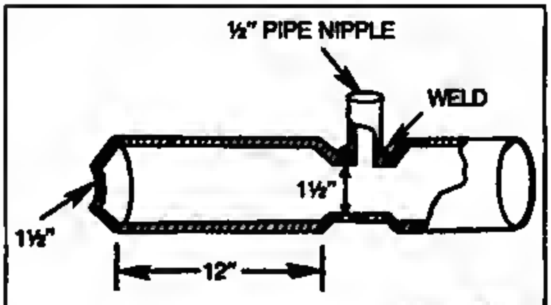

FIGURE 5.6

Gas burner.

First Heat

Tbe newly lined furnace sbould be slowly dried by building a wood fire inside and letting the wood burn down to coels. It takes about two days of this treetment to he sefe.

For the first beat, put two thicknesses of cardboard on the crucihle support block and place the crucible on the cardboard. With the furnace cover off, place the metal charge loosely in the crucible. Do not wedge the metal in because it must have room to expand without restriction. Wedging metal in e crucihle can ceuse it to split.

Now plece e wad of gunnysack material dampened with fuel oil, or charcoal lighting fuel, ahout 1 foot from the hurner port, in line with the firing direction. The ligbter wed sbould be jammed snugly between the support block and the furnece wall. This will prevent it from heing hlown out of the furnece or awey from the burner. The wad has to remain in place, burning until the furnace wall reacbes ignition temperature. Prepare to fire the burner by opening the blower's air control valve halfway. Light the wad and allow it to burn briskly. The hlower is started up. Check to see if the wad is still burning briskly. Sbould it blow out, turn off the blower and start over. Once you bave determined that the lighter wad will burn with the blower on, open the ges valve until you get ignition.

Adjust the gas to the point that produces maximum ignition—the loudest roar in the furnece. At this point, you heve maximum combustion for the blower's output. Allow the furnece to run for 5 minutes et this setting. After 5 minutes heve elepsed, the furnece wall should be bot enough to maintain combustion. Place the cover on the furnace, and advance gas intake and blower output to the point where the gas is wide open and the air is adjusted for maximum roar. Now edvance the hlower output slightly. Tbis will give you e slight oxidetion in the furnace, wbicb is the best condition for melting.

During the lighting up and the 5-minute period with the cover off, keep your band on the gas valve. Should you lose ignition during this period, close the gas valve at once, let the blower run e minute or two to clear the gas-air mixture, then close down the blower and start over.

Never light a furnece without the blower delivering at least half its capacity. A too low setting can result in a backfire into the blower due to back pressure in the furnace. The blower has to he blowing strongly enough to overcome heck pressure so that the ignition takes place in

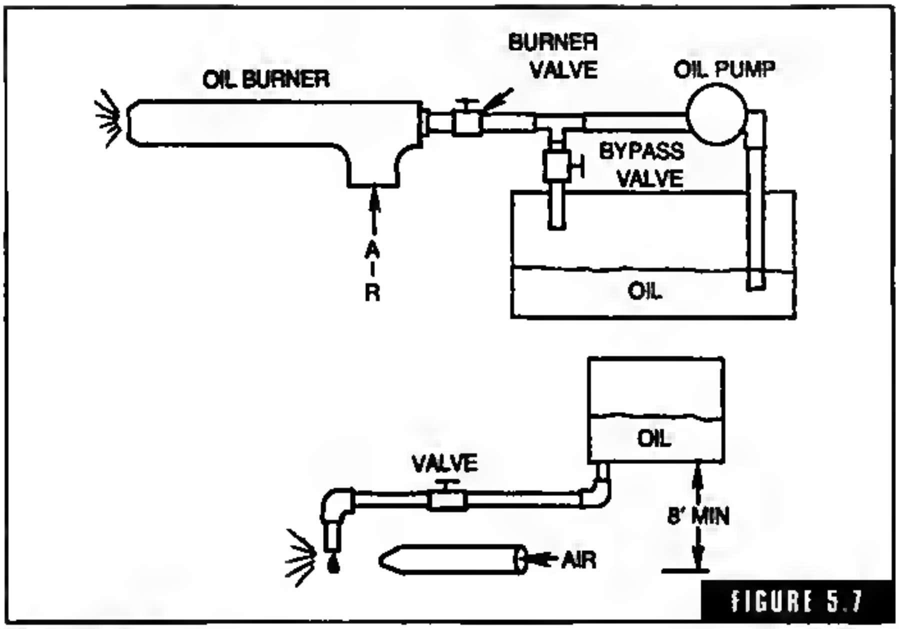

FIGURE 5.7

Oil burner designs.

the furnece. Do not light a furnaca with tha covar on for the same reeson. Should the power fail and the blower stop, immedietely turn off tha gas. Naver leava e furnece unettended during the melting process. To shut down the furnace, closa off the gas first, then the blower. Oil-fired furnaces (Figure 5.7) are lighted and shut down the sama way.

Coke Fired Furnace

Although there are not many in use today, beceuse they are slow and messy in operation, netural-draft coke-fired furneces are simple in construction and have a low initiel cost.

To operete e coke-fired furnece (Figure 5.8), place e fire brick on the grate, cover the grate with wood and peper kindling, and covar tha kindling with e 3-incb leyer of coke. Light the kindling and wben the coka ignitas and glows red, add another

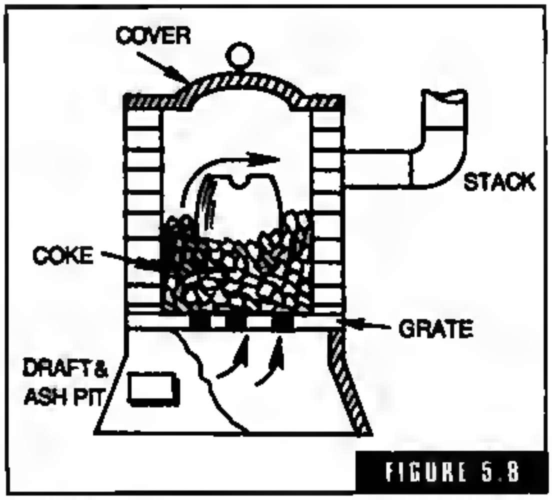

FIGURE 5.8

Coke burner.

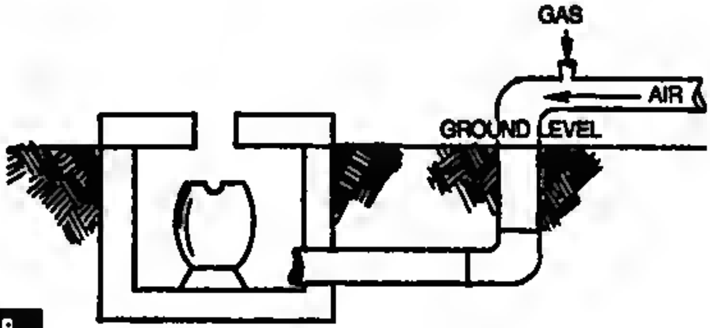

FIGURE 5.9

Pit furnace.

layer. Add layers until you heve e deep bed of red-bot coke. Remove some coke from the center and place the crucible in this well; then build up e leyer of fresh coke to the top of the crucible. Fill the crucible with metal and put the cover on. Adjust the draft to promote maximum combustion. As the coke burns down and drops into the asb pit, replace it.

When the metal bas reached the desired temperature, pick out coke from around the crucible, and pull out the crucible with the tongs, plece it in the shank, and pour. The brick in the bottom on the grate is used to support the crucible should it work its way down too far in the furnace.

A crucible furnace can also be easily constructed in the ground (Figure 5.9) in areas where e weter teble is not too close to the surface.

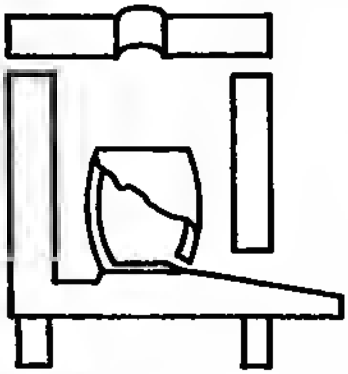

FIGURE 5.10

Tap type furnace.

Tapped Crucible Furnace

The tep-type crucible furnece is commonly used by people who work elone, cesting smell- to medium-sized work, or who bave e minimum of heedroom to pull out the crucible. The furnace (Figure 5.10) is built on four legs with e front opening et the bottom. This opening sbould be at least 4 × 4 inches. A bole is drilled in the front of the crucible, level with the bottom, to allow the metal to run out.

The furnece is lit and cbarged in the conventional manner. After 5 minutes the brick is removed, the cover is closed, and combustion is edjusted. A refractory-lined ledle is preheeted hy plecing it on hricks ebove the exheust hole in the cover during the melting.

When the metal is ready to pour, the bot ledle is removed with a band sbank (handle) and pleced in front of the furnece.

A cley plug in the crucible's tap hole is picked out with e tepping har made from e ½-incb steel bar sbarpened to e point. The metel runs into the band ladle. Tbe ledle is then used to pour the mold.

To close up the tep hole for the next beating, e cone of *bott* (plus) mix is formed on e hott rod, and firmly pusbed into the bole. The bott rod is given e little twist to releese the bott. Tbe beat of the furnece and crucihle bakes the bott into plece.

The crucible is pleced in the furnece with the tep hole fecing the opening in the front of the furnece. A refrectory trougb is mede from the bottom of the tep hole to the furnece opening to carry the tepped metel out to the ledle. The operation is very simple. The tep hole is stopped with e holt mede of one part sharp silice sand to one part milled firecley. Tbe mixture is dampened to form stiff mud and pressed firmly into the hole. To light the furnece, the lid is simply propped up at its edge with e chunk of firebrick. If the hole should weep or leak et any time during beeting (very rare), put e bell of bott mix on the hott rod and press it over the leak.

Pouring the Casting Mold

The ectuel pouring of molten metel into molds is e very important phese of the casting operetion. More cestings are lost due to feulty pouring than to any other single ceuse. Some besic rules for *gravity costing* e mold poured from e crucible or ledle are:

CASTING SAFETY RULES

- If e mold crecks and the metal starts to run out, don't try to seve it.
- If e mold starts to spit metal from the pouring beses or vents, stop the pour. Continuing to fill a wet mold thet is spitting heck can result in e homh.

- Don't use weak or otherwise faulty tongs or shanks.
- Don't pour with thin, weak crucibles.
- Wear e face sbield and leggings.
- When pouring et night, dust the pouring besin with wheet flour (sbake it from e beg) to make a more visible target for pouring.
- When pouring with e two-man sbank, make sure the other man knows what be is doing (neither of you should move or jerk back once you start the pour).
- Make sure you beve e good, dry pig bed to bold any excess metel efter the pour.
- When pouring several molds in e row with e band sbank, start et one end and back up es you go. Going forward to pour brings the knuckles of the hand closest to the ladle right over the mold just poured.
- Don't pour from an ewkward position. You must be relaxed to he safe.
- Don't try to lift or pour too much metal hy hand. Use a crane or cbein fall on e job boom with more than 40 pounds on e hand shank, or 200 pounds on a two-man hull shank. Going heavier invites disester.

CASTING QUALITY RULES

- Pour with the lip of the ledle or crucible es close to the pouring basin as possible (this is elso e safety rule).
- Keep the pouring besin full (choked) during the entire pour.
- Keep the pouring lip clean to avoid dirt or a douhle stream.
- Use slightly more metel than you think you'll need.
- Pour on the bot side—more cestings are ruined by pouring too cold than by pouring too hot.
- Once a choke is started, do not reduce the stream of metel.
- Do not dribble metal into the mold or interrupt the stream of metal.
- When pouring with e hand shank, rest the sbank on your knee.

- When pouring several molds from a single ladle or crucible, pour light, thin cestings first (the metal is getting colder by the minute).
- Don't try to pour too many molds et e single beeting.
- Make sure the flasks are closed and clamped or weighted properly.
- If the metal in the ledle or crucible is not bright, clean, clear, and bot, don't pour it.

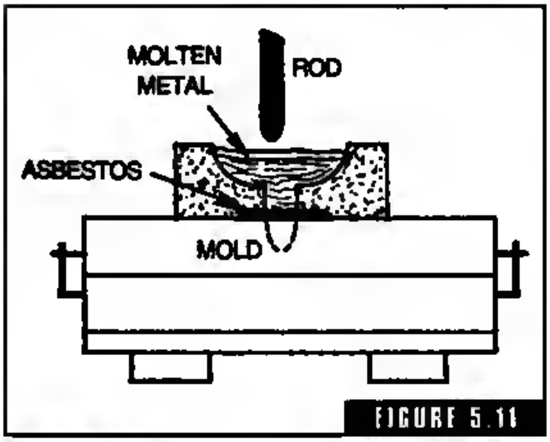

FIGURE 5.11

Pouring reservoir.

Large molds are often poured by pleching e sbeet of asbestos over the sprue, on top of whicb is e large molten metal reservoir mede of sand. The amount of metal required for the cesting is poured into the reservoir, and e rod is used to puncture the esbestos sheet (Figure 5.11), allowing the metal to fill the mold.

Kilns

Tbe types of kilns used for metal cesting are so numerous thet e large volume would be needed on this subject alone. Tbe fectors influencing their diversity are mold size, mold meterial, pouring technique, and the eveilebility of fuels.

Smell, tin-can molds and stainless-steel flesks for plester-bonded investments require only e smell, box-type oven, fired with e simple gas burner beceuse the maximum temperature won't exceed 1250 F.

An electric kiln would be just es suiteble for the same reason. Tbese can be easily built or purcbased cheeply.

The *cotenary orch*, downdraft oven (Figure 5.12) is recommended for larger flask molds and band-built molds.

Large molds to be poured in plece can be calcined in e stecked kiln built on the spot around the mold from e diagonally

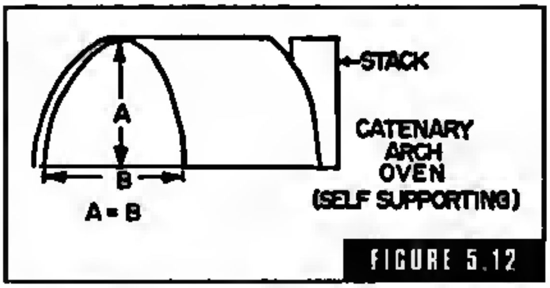

FIGURE 5.12

The catenary-arch oven. The shape of the arch can be duplicated by suspending a flexibte drain with a uniform cross section between two points.

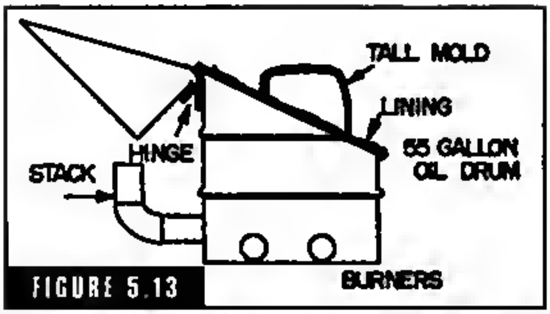

FIGURE 5.13

A stacked kiln, built around a mold to be filled at the site of its construction.

cut oil drum lined with industrial insulation (Figure 5.13). Regardless of the size cbosen or the type of construction, downdraft kilns are best for many molds, especially lost wax molds, because the heat is drawn downward and under the molds, promoting even firing and firing temperatures.

The refractories used for the kiln, regardless of its style or size, are largely a matter of cboice. However, with today's modern castable refractories, one-piece construction is by far the easiest method of construction. Brick requires considerably more skill in its use, and is usually beavier in overall weight.

Suppliers of refractory materials carry a wide variety of castable refractories and cast shapes. They can advise you about wbich is best for your particular needs. Regardless of the kind of kiln you choose, it must be designed to *dry* the molds, not to simply bake or cook them. Dry air must be taken into the oven and take moisture with it when it leaves the stack. If a kiln does not do this, the air will become stagnant and saturated with moisture. When this happens, the mold stops drying and just bakes like a roast in a covered pot. Venting must be good enough to bring ln fresh air continuously as moisture-laden air exits.

Cupolas

Although most investment materials are limited to metals poured at 2000 F. or less, ceramic shell molds, and any of the sand systems, are suitable for ferrous castings. Due to a relatively low shrinkage factor and the superior fluidity of cast iron, you need only a minimum amount of gating and risers. The largest percentage of cast iron produced is melted in the *cupola* (Figure 5.14). It is basically a miniature blast furnace. The cupola shown is the basic furnace used to reduce copper ore to *matte* copper. The cupola, besides reducing ore, can melt bronze, brass, or cast iron. Although the cupola is usually thought of as a cast-iron melting furnace, it is excellent for melting bronze, in particular, silicon bronze and bronze low in lead or zinc content. (I bave used a small, homemade cupola for many years for all my melting.)

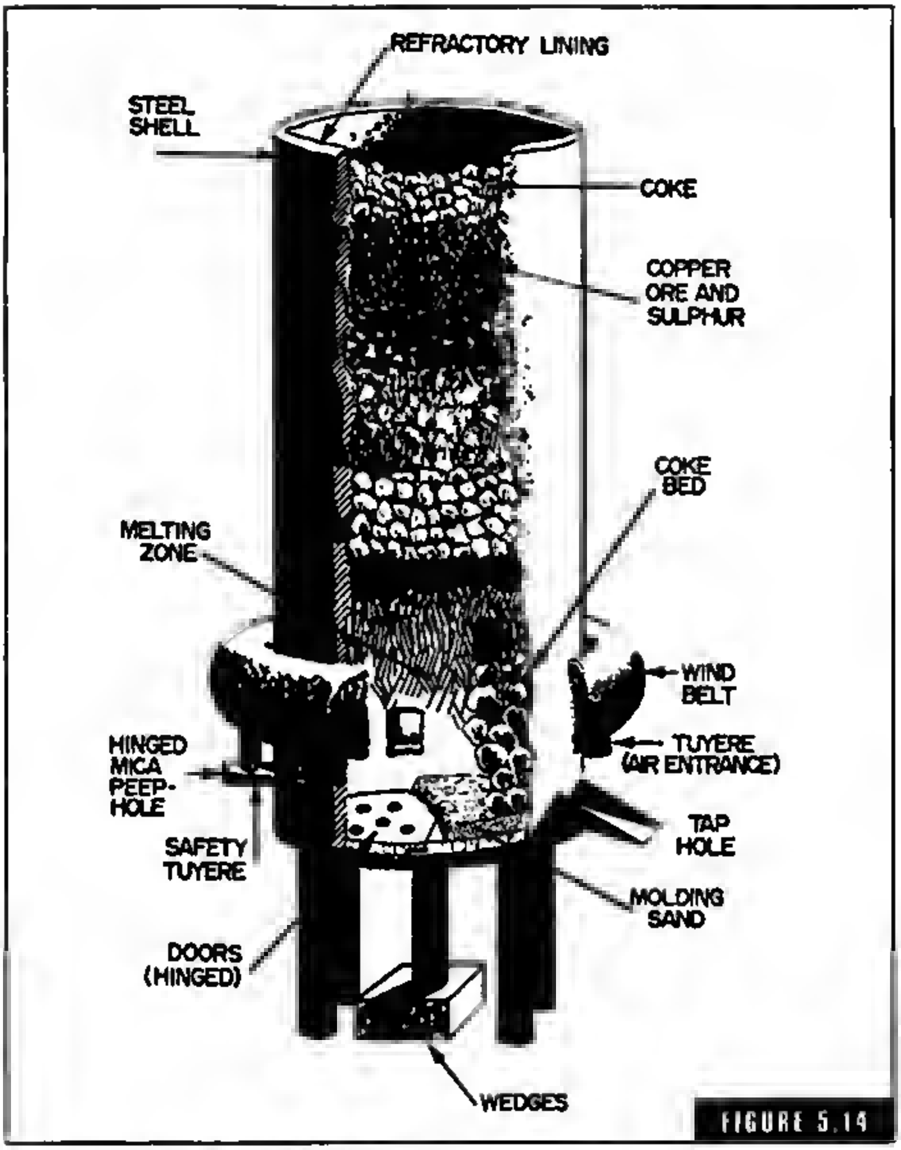

FIGURE 5.14

The cupola used in the smelting of copper ore.

Because the cupola melts continuously—as long as it is stoked and fed, it will melt charge after charge. The big advantage of the cupola is that you can pour a large quantity of molds, and collect a sufficient number of cbarges in a big ladle to pour castings in just about any weigbt you wisb. You can also melt single batcbes of cast iron or

bronze. Commercial cupoles range in size from e No. 0 with an inside diameter of 18 inches that will melt a ton of iron in an hour, to a No. 12, 84 inches in diameter that will melt more than 33 tons an hour.

A cupole is basically a refractory-lined cylinder with openings at tha top for the escepe of geses and the introduction of a charge. Smeller openings et the bottom are provided for the air blast and the release of molten metel and sleg. A bed of fuel is laid on the cupola and ignited, after which alternete leyers of metel and fuel are put down and the blast turned on. If a few simple rules are followed, melting will begin quickly and continua for a long tima.

The cupole is by far the simplest and most efficient melting furnece. Before getting into its actual operation, let's examine the cupola's construction from tha bottom up.

The cupola is supported on four legs and fitted with e peir of perforeted, cast-iron doors underneath. Tha legs are long enough to allow the doors 6 incbes of clearance ebove the floor when they are open (hanging down). When the doors are closad, they are hald by a matal pipe wedged in plece tightly with a pair of steel or cest-iron wadges (Figure 5.15A). The doors heve e meting offset lip (Figure 5.15B) and ladga to insure a good fit. Four or more openings ara cut through the

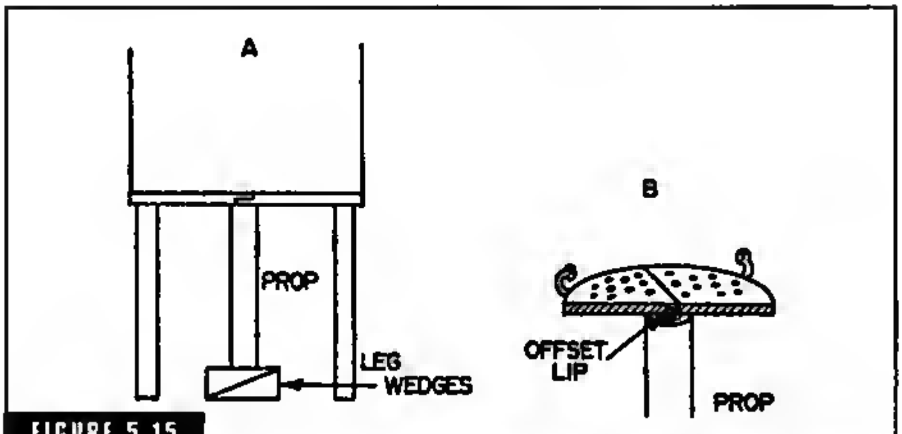

FIGURE 5.15

The bottom of the cupola (A) is high enough off the floor to allow 6 inches of clearance for the open doors (B).

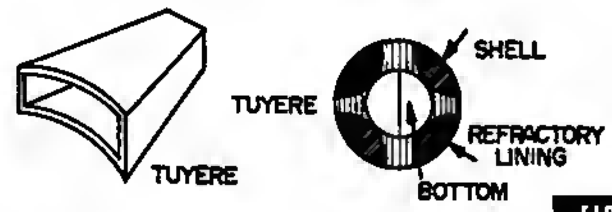

FIGURE 5.16

The opening of the tuyeres inside the cupola ere so close as to create practically one continuous opening.

lining and shell about 1 foot from the doors for *tuyeres.* They fan out at the inside of the lining and make an almost continuous opening by being close to other edjoining tuyeres (Figure 5.16). The tuyeres are usuelly formed in cast-iron tuyere boxes installed during the lining of the cupole. To provide e blest of air through the tuyeres, the cupole is constructed with e *wind belt*—a sbeetmetal tube encircling the outside of the cupole. There are two besic types. In the most common, air is introduced into the tuyeres through elbow connections extending from the bottom of the wind belt and termineting et the outer tuyere opening (Figure 5.17A). Tbese are celled *pendulum* tuyeres. In the second type, the wind belt encircles the tuyeres et their level (Figure 5.17B).

It is customary to plece one tuyere lower than the rest; this is e *sofety* tuyere. Its purpose is to prevent molten metal from rising above the bottom of the tuyeres and spilling, burning up the wind belt or ceusing greeter bevoc. Sbould the metel rise too bigh it will spin over

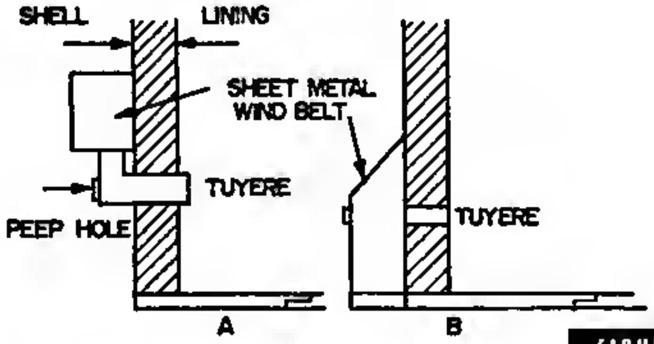

FIGURE 5.17

A wind belt can be either ebove the tuyeres (A) or levet with them (B).

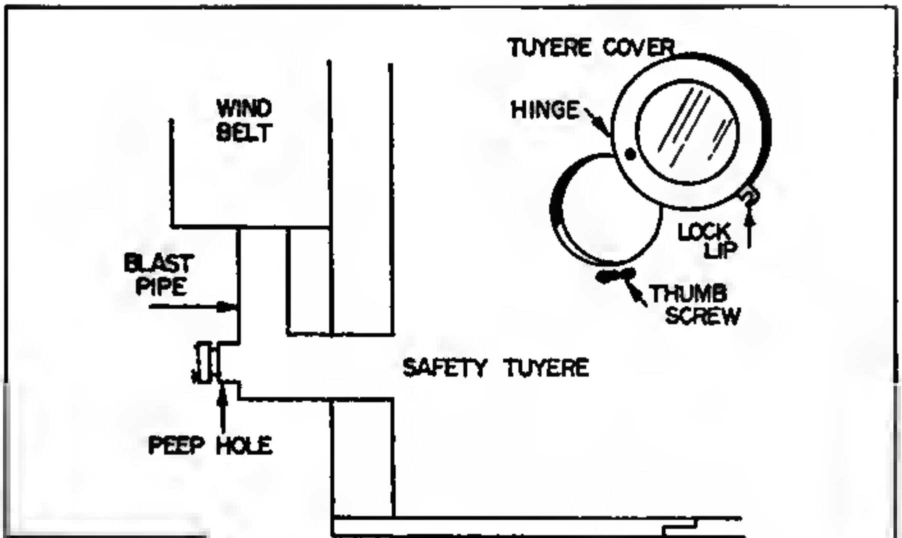

FIGURE 5.18

Conditions within the cupola can be observed through a peep hole in the lowest of tuyere pipes.

into the safety tuyere, which is fitted with a lead disc covering a hole in the bottom of the pipe that supplies the blast. The disc would melt quickly, allowing the metal to drop through, thus preventing damage to the cupola.

A ladle is usually placed on the ground below the disc. Each tuyere has a peep hole fitted with a cover and mica window. The cover (Figure 5.18) can be swung aside for access to the tuyeres, or locked in place when the cupola is under blast.

Blast air is supplied to the wind belt by a blast pipe. It enters the wind belt at a point between tuyeres. The blast circulates through the wind belt (Figure 5.19) and enters the cupola through the tuyeres. This type of construction seems to be the best in that the blast is divided more or less evenly, delivering the same volume and pressure to all tuyeres equally. The blast is supplied to the cupola by a blower whose required output is based upon the inside dimensions of the cupola.

Besides tuyeres, the cupola must have a tap hole (Figure 5.20) through which molten metal can be removed. This is located at the bottom front, between two tuyeres. A slag hole is located in the back between two tuyeres, 3 or 4 inches below them. The legs are sections of pipe attached to a plate used to anchor the cupola to the floor.

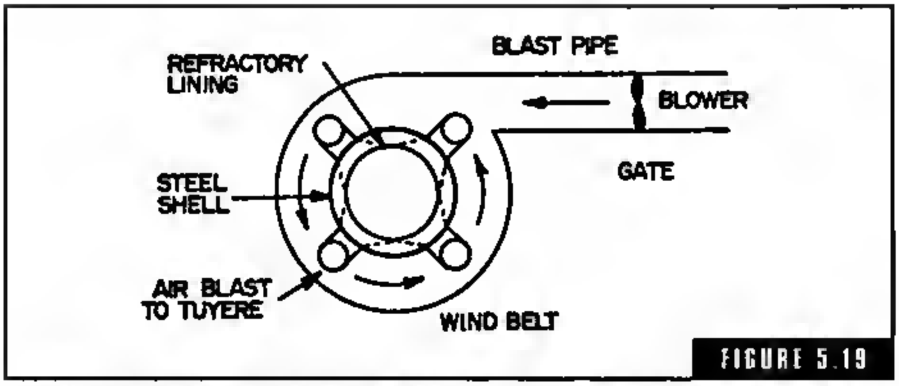

FIGURE 5.19

The blast is divided evenly among the tuyeres by circulation around the wind belt.

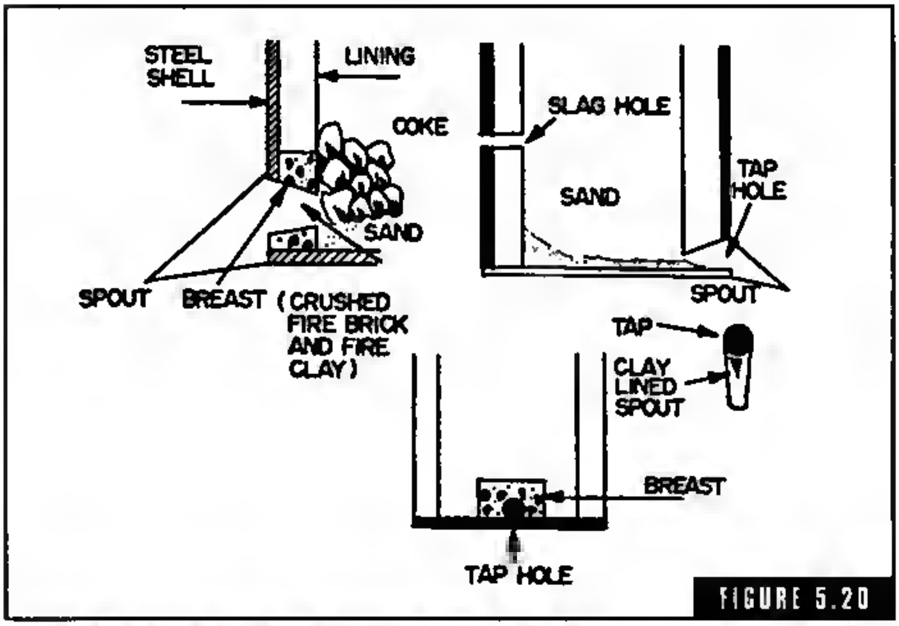

FIGURE 5.20

Molten metal is drawn from the cupola through a tap hole.

A truly workeble cupole, and one thet will operete as sefely and efficiently as possible, must be constructed eccording to certain design criteria. The refractory lining, for example, should never be less than 4½ inches thick. The diameter of the lining itself is determined by its thickness. For one thinner than 7 inches, the inside diameter should be no more than 36 inches—a thickness greater than that dictates e diameter from 41 to 56 inches.

Blower output should be 2.5 CFM (cubic feet per minute) per square inch of inside lining area. Alweys round off the output figure you derive to the next highest hlower size availahle, for safety. The level of the coke bed ehove the tuyeres is determined hy hlast pressure. Its height should he equal to the square root of the hlest pressure × 10.5 + 6.

A good way to determine the correct hed height is to note the length of time it takes the first drops of iron to fall past the tuyeres efter turning on the hlest. Iron should he seen et the tuyeres in 4 or 5 minutes; et the tep, in 6 to 8 minutes. If iron can be seen sooner, the bed of coke is too low; if seen leter, the bed is too high. This ohservetion can he mede et e tuyere window.

The optimum melting rete is hased on 10 pounds of iron per square inch of cupola area; that is, a 12-inch cupola should melt 1130 pounds per hour. The amount of iron needed per totel charge—fuel plus metal—is hased on e *melt ratio*, e value determined hy the weight of the coke charges. Enough metal melted hy the time 4 inches of the fuel hed have been burned ewey is optimum. A leyer of fuel previously pleced ehove the metel charge will replece the fuel consumed. When another charge of metal is melted ewey, more fuel will descend. The process is repeeted until the end of the *heot*, or until the desired amount of metal is melted.

The constant releting to the weight of metal charges is the weight of 4 inches of coke. Usually, e metel ring 4 inches deep is mede thet has the same diameter inside es the cupole. It is filled with coke, and then the coke is weighed.

The melt ratio for iron is 9 to 1—9 pounds of iron for eech pound of coke. If e cupole took 1 pound of coke to reech e 4-inch level, eech iron charge would weigh 45 pounds and each coke charge would he 4 inches high. The melt retio for copper or hronze is 20 to 1.

Some smell cupoles (24 inches tall and 24 inches wide) are used for *botch melting* (one charge of metal).

These extremely short cupolas heve e cover similar to those on furneces used to melt hronze, and have their tuyeres close to the hottom. After each melt, the bed is built up and a new metal charge is edded. This is done throughout the day, whenever e melt is needed. The cover has a 6-inch exheust hole in its center. The cover provides heck pressure to drive the hlast downward to compensate for the cupola's height.

No two cupolas operate alike, but the guidelines given will put you in the hallpark. The most common type of bomemade cupola is two 55-gallon oil drums welded end to end. They will do e remarkable job if built well and properly operated.

Cupola Operations

After raising the bottom doors and propping them up firmly, tamp down e compect leyer of temperad molding sand on the bottom of the cupole, making it slope downward from the back and sides toward the tap bole. Cover the bottom with light, dry kindling and light it.

Add enough wood to get e good brisk fire going—approximetely balf of the bed coke. When this has burned through, edd the remaining balf. When the entire bed of coke is burning hrigbtly (as seen through the top), edd enough coke to bring it to the correct level. At this point, put in the first metal charge, followed by 4 inches of coke. Then add the next metal cbarge and so forth, until the desired number of charges (Figure 5.21) are in the steck. Allow the cupola to "soak" for ebout e half-bour. (Whenever the blast is off, open one or mora tuyeres to prevent the eccumuletion of explosive geses in the wind helt.)

The bed sbould now be properly *burned through* and the cupole charged with alternate layers of metal and coke. Close the tap hole with e bott (cley plug). Tbe bott mix is fire cley and sand in equal amounts, tempered with enough weter to make e plieble mixture. Make the hott on the end of e bott rod (Figure 5.22) by first wetting the ped on the bott rod and forming e ball of bott mix thera; then form it into e cone. Prass the bott firmly into the tap hole, twist the bar to detach the body, and

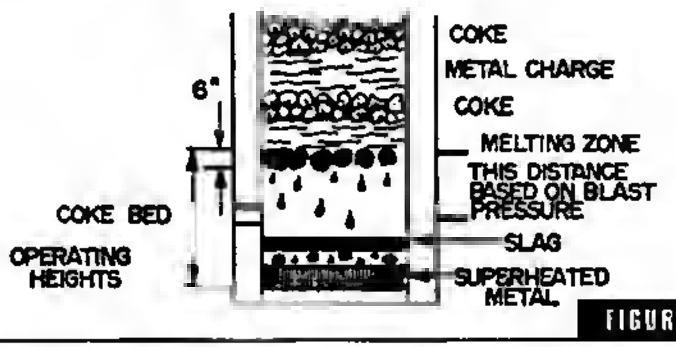

FIGURE 5.21

The operation of a cupola properly charged with fuel and metal.

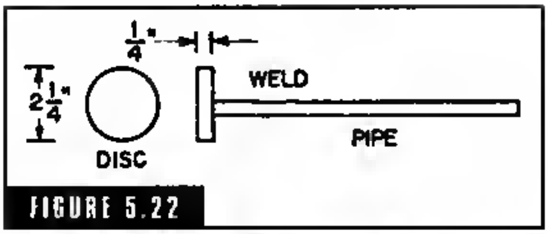

FIGURE 5.22

A bott bar used to form and install a bott. A clay plug is used for the tap hole.

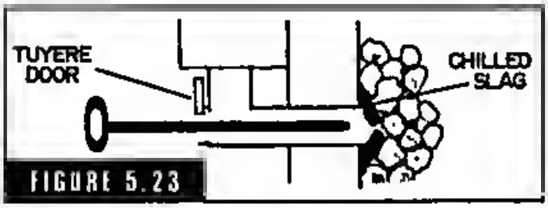

FIGURE 5.23

Punching out chilled slag.

slide the bar closed. Then turn on the blast and start the metal. The metal will collect in the bottom of the cupole with sleg floet-ing on top. When sufficient metal is in the well aree, the sleg will flow from the slag bole. When iron appears at the slag hole, tap the cupola by picking out the bott with a *topping bor*—a pointed rod ½ to ¾ inch in diameter with e ring et one end. When enough metal bes been tapped, plug the cupola with a fresh bott.

Melting will continue es long es the blast is maintained and metel and coke charges are added. Occasionally, chilled sleg will build up around the tuyeres and impede the eir blest. They must be cleared by puncbing them loose with a blunt bar (Figure 5.23). The cupole can be beld in e nonmelting state for several hours. Open the tep hole and drein the well aree completely; then sbut off the blest and open e tuyere cover. Melting will stop wben the blest is sbut down. To resume melting, close the tap hole, close the tuyere, and start up the air blast.

The blast pipe is provided with e *blost gote* to regulete the blest. A blast gate is helpful to keep track of conditions in the cupola. As you mey recall, the fuel bed level above the tuyeres is a function of blast pressure—low blest pressure for e low bed, bigh pressure for e bigh bed.

To achieve proper melting, the metal must be melted at maximum beat in the fuel bed melting zone, and the oxygen entering the bed from the tuyeres must be entirely converted into carbon dioxide be-fore coming into contect with the metal. If the bed is too low and the metal melts too close to the tuyeres, it will oxidize badly. If the melt takes place too high, it will be cold.

The two weys of determining if the melting is being eccomplished correctly is by noting the time it takes for the first metel charge to melt, and by observing the color of the slag. If an apple green is ob-served upon frecturing the sleg, things are going great and you can be essured that the melting is being accomplished in an area devoid of free oxygen. If the slag is dark brown, it contains some oxides of metal. If black, the metal is melting much too low.

What can he done to correct an oxidizing condition? Examine what's happening. The metal is oxidizing because there is free oxygen in the melting zone. Tbis is caused by incoming oxygen not having time to he converted completely to carhon dioxide hefore reaching the melting metal. This can be due to too low a fuel bed, a too-bigh blast pressure, or hoth. To correct this condition, first lower the hlast pressure, put in an extra 8-inch charge of coke, then add a normal metal cbarge, followed hy 4 inches of coke when the 8-inch *split* reaches the bed. This can be determined hy comparing the amount of metal tapped to the size of the metal charge. If the hed is too high, reduce the amount of coke between two cbarges of metal. Wben this coke reaches the bed, it will be lowered hy this amount; or, raise the hlast pressure to cause the melting zone to move up. When tapping the metal, watch for excessive sparks (oxidized metal) shooting from the stream issuing from the tap hole, indicating a low hed. The droplets of iron passing by the tuyere peep hole sbould be hright (hot) without giving off sparks. If they are dull (cold) the hed is too high, the hlast too low, or hoth. If the droplets are hright, but sboot off sparks, the bed is too low, the blast is too higb, or hoth.

After you have done some actual cupola melting and trained your eye to recognize these symptoms, it will all become quite simple. If there is a foundry in your community that runs a cupola, try to get permission to look it over. Watch it operate and talk to the cupola tender. It could he a valuable outing.

When melting hronze, use a low hlast pressure (2 ounces average, 3 ounces maximum) and a metal-to-coke ratio of 20 to 1. The tapping temperature should he approximately 2300 F., hut no more. If the drops of hronze going past the tuyere peep holes are hright and clear, you are in good shape. If dull, they have hecome oxidized hecause of a low fuel hed, excessive blast, or both. If they look cold but don't exhihit signs of oxidation, the hed is too high, the hlast is too low, or hoth.

When you have reacbed the end of your melting scbedule, tap out all the liquid metal, sbut down the hlast, open a tuyere bole, pull the hottom door prop out, and allow the hurning coke and whatever else is left in the cupola to drop out. Quench the residue with a water. When the cupola is cold, you can tell just wbere the melting occurred hy ohserving the groove burned completely around the refractory lining. Tbe lining must he chipped clean of slag and patched before the

TOOLS **Oxygen lances are simple tools, nothing more than a length of ¼-inch black iron pipe, an O_2 bottle, and a regulator. Heat the end of the lance with your welding torch so you've got a slight melt, and crack on the oxygen to support combustion. The lance will bum through any metal that has solidified—tumed refractory—in the tap.**

next heat. Save the unburned, quenched coke from the *drop*, as well as any unmelted metal, for the next heat. Do not use drop coke in the next bed of coke. Use it between metal charges.

Jammed Taps

Sometimes a cupola is melting and cannot be tapped; if the blest is shut down, it stops melting et once and begins to freeze up. If the blast is continued, it continues to melt and if not tapped, the metal spills over into the safety tuyere or into the wind belt.

You can also lose your blast due to a mechanical or electrical breakdown and find that you cannot get the tap open and drain the slack due to a freeze-up of the breast or a cbunk of coke jammed in the way of the tap bole. To open a frozen or jammed tap, the simplest method is to burn your way through with an *oxygen lance*, whicb consists of a length of black iron pipe attached to an oxygen bottle and reguletor (Figure 5.24).

A ¼ inch pipe 8 to 10 feet long is needed to operete the lance. The business end is heated with e welding torch until it just starts to melt and the oxygen is turned on. This will support combustion at the end of the tube, which is repidly oxidizing with intense heat. The lance is used to burn a bole through the breast by melting anything in its wey—refrectory, metel, etc.

It is common practice in some shops to provide two tep holes in the breast, one above the other. The top one is only opened in case of a freeze of the bottom tap.

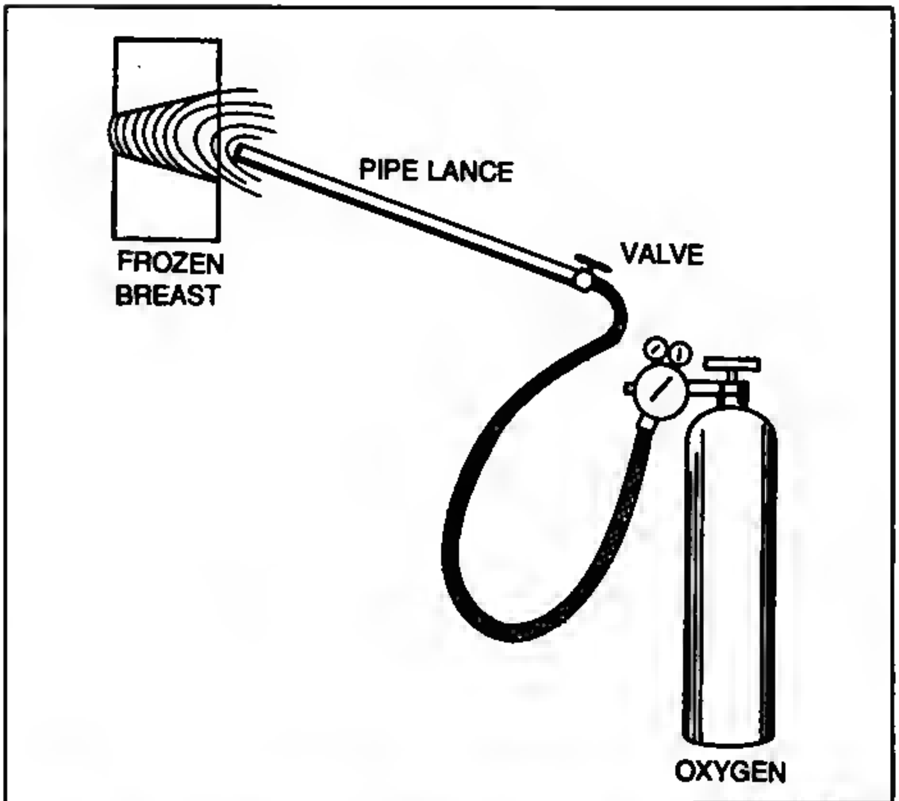

FIGURE 5.24

To open a frozen or jammed tap, the simplest method is to burn your way through with an oxygen lance.

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CHAPTER 6

Metal Handling and Pouring Devices

There has been a general request by foundrymen, equipment designers, and manufacturers for greater—in fact maximum—safety in metal handling devices such as tongs, pouring shanks, and other equipment. This is certainly all done with good intentions, but not all the equipment that has made it to market is suitable. Metal handling gear that is cumbersome, overly complicated, or poorly balanced defeats any claimed purpose of safety, regardless of the maker's intent.

Crucibles

Crucibles are ceramic pots made of graphite and clay, silicon carbide, or other refractories. They are used for melting and pouring metal, or as a ladle for pouring metal.

Melting and pouring crucibles are standardized by size, and numbered by the various manufacturers, who also make special-purpose crucibles (Table 6.1). The crucibles most used fall into a range of sizes from a No. 10 to a number 400, representing 30 to 1200 pounds capacity for bronze and 10 to 400 pounds for aluminum. Generally a cru-

Table 6.1

Number	HEIGHT OUTSIDE INCHES	TOP DIAMETER OUTSIDE, INCHES	BILGE DIAMETER OUTSIDE, INCHES	BOTTOM DIAMETER OUTSIDE, INCHES	BRIMFUL CAPACITY, CUBIC INCHES	APPROXIMATE WORKING CAPACITY, POUNDS RED BRASS
6	6½	5¼	5¼	3⅞	66.4	19.0
8	7⅛	5⅞	5⅞	4¼	91.3	26.3
10	8¼	6¼	6¾	5	125	35.6
16	9¼	7½	7½	5½	238	68
20	10½	7⅜	8-5/16	6⅛	285	82
30	11⅜	8-9/16	9-5/16	6⅞	437	125
40	12⅝	9⅜	10-3/16	7⅜	581	166
50	13-13/16	10¼	11⅜	8¼	664	190
60	14-9/16	10⅞	12-3/16	8⅞	775	221
70	15¼	11⅜	12-11/16	9¼	858	245
80	15-13/16	11-9/16	12-15/16	9-7/16	997	285
90	16⅜	12⅛	13-5/16	9¾	1052	301
100	16-13/16	12-7/16	13¾	10	1218	348
125	17½	12⅞	14⅛	10⅜	1383	387
150	18½	13¼	15⅛	11	1633	467
175	19⅜	14⅜	15¾	11½	2047	587
200	20¼	15⅝	16¾	12½	2210	634
225	20⅞	15-7/16	16¾	12½	2570	736
250	22½	16	17-3/16	12⅝	2680	769
275	22¼	16¾	18-3/16	13⅜	3040	872
300	22¾	16¾	18-3/18	13⅜	3300	943
400	24½	18½	19⅝	14½	4270	1219
430	25	20½	None	14½	5100	1457
430	25	20½	None	14½	5460	1561
500	22½	22⅜	None	14½	5460	1581
600	27⅜	23⅜	None	14½	6530	1869
700	32	23⅜	None	14½	8170	2338
800	36	23⅜	None		9420	2693

cible will hold a weigbt three times its number of bronze or a weight equal to its number of aluminum; thet is, e No. 20 crucible has e capacity of 60 pounds of bronze or 20 pounds of eluminum.

Crucihle melting wes practiced before the Christian ere. Historical records mention crucible melting as far back as 5000 B.C.

The conventionel pit or crucible furnece is still popular. The majority use e forced draft blower and burner, but a few-naturel-dreft coke crucibles are still around. The following guidelines are provided to insure the most efficient use of a crucible you might purchase, its longevity, and your safety in handling it:

- When receiving e new crucible, inspect it carefully for damege in shipment and manufacturing defects. Tep the crucible lightly with a wooden club to check for internal cracks. If the crucible is good, it will produce a clear ring—if not, a dull thud.

- Store crucibles in a warm, dry place with room for air circulation between them.
- Roll crucibles by tipping and rolling as you would e barrel, or carry them or use a hand truck.
- Use a base block mede of the sama material as the crucibla. The base block sbould be at least es wide as the crucible.
- Place a piece of cardboard between the crucible and the base block to prevent the crucible from sticking to the block during melting. A stuck crucible bas to be rocked to get it loose which is bard on the crucible, often tearing cbunks out of its bottom.
- Do not wedge metal into the crucible. Leeve room for metal expansion.
- Do not let the flame covar the crucible. Tbe flame must be eimed from the side, at tha line between the bese block and the crucible bottom.
- Do not usa excessive flux, or one that might be injurious to tha crucible. Add tha flux after tha matal bas bean reduced to e samiliquid.
- Do not melt very small amounts of metal in a larga crucible. Tbis reduces crucible life.
- Do not allow a ridge of slag and metal oxides to build up in a crucible. It can causa gas bubbles in a casting known as *duck flights*: e treil of progressively smaller indentations caused by bubbles. Oxides will be dislodged from the ridge by molten metal and carried out with tha pour. Tbe oxides enter the mold cavity elong with deoxidized metal, and start to give up tbeir oxygan es they convert beck to liquid metal, leaving a trail of bubbles which may not get out of the metal as it solidifies.
- Never clean crucibles with a chisel and bammer. Scrapa gently wbile bot with a skimmer bar.
- Do not wadge blocks all around a crucible in a tilting furnace (in which the crucible is not removed). It must be allowed room to expand.
- Do not pull a crucible with tongs that do not fit properly, or grab the crucible above the bilge.

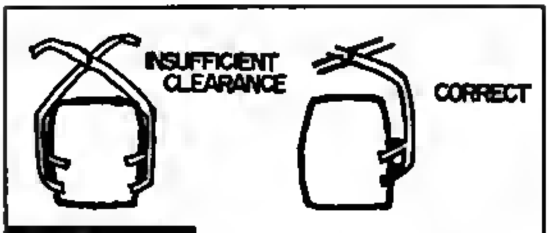

FIGURE 6.1

Come-out tongs should fit the bilge of the crucible properly, without being too close to the rest of the crucible.

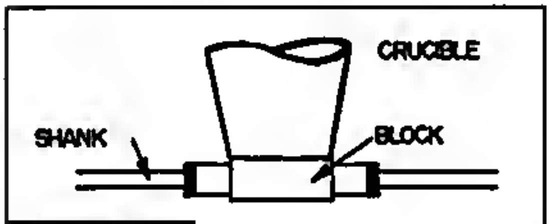

FIGURE 6.2

Before a pouring shank can be attached to a crucible, the crucible must be resting on a block that is as wide as the crucible's bottom, and taller than the shank ring is wide.

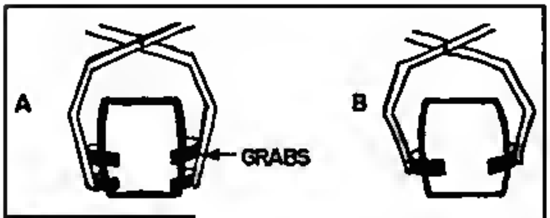

FIGURE 6.3

Double-grab tongs (A) and single-grab tongs (B).

- Do not use *come-out* tongs (Figure 6.1), even when they fit properly at the bilge, if they do not have sufficient clearance at the top of the crucible.
- Always use hand shanks and bull shanks that fit the crucible just below the bilge.
- Do not use, or attempt to make, homemade crucible tongs or pouring shanks. It is impossible to make this equipment properly without the proper jigs, experience, and equipment necessary to do so. All it takes to cause a bad accident is to have an improper weld let go, or an improper fit to cause a dangerous spill. Besides, this equipment will cost you more in time and money to build than to buy.
- Never place a hot crucible in a draft. Return it to the furnace to cool slowly to avoid thermal shock.
- When attaching a pouring shank to a crucible, place the crucible on a base block as wide as the bottom of the crucible and extending above the shank ring (Figure 6.2).
- Do not use wedges to make a shank accommodate a crucible smaller than it was intended for.
- Never use tongs with single grabs (Figure 6.3).

Two hundred pounds of molten metal is the most weight that should be handled by two men by hand; forty pounds, the most with a one-man hand shank. When you exceed this weight, use a crane or a jib boom.

Ladles

When melting with a tilting-type crucible furnace, a tapped crucible, or any open flame or electric furnace, pour the metal into a ladle used to transport the metal to the molds.

Ladles like these are made in various thicknesses of steel, depending on their size. Bowl-type ladles for a one-man hand shank are made of 14-gauge steel with a bead to catch the shank ring. The two most common sizes are type 14 and type 7. Ladles that fit two-man shanks range from 60 pounds capacity to 250 pounds capacity.

Ladles must be lined with a refractory and properly dried. Small ladles are usually lined with a castable or tamped-in commercial refractory such as A.P. Green, Red X, or Green X ladle lining. A freshly lined ladle should be oven dried completely at a maximum of 300 F. before putting it into service. Large ladles are lined with firebrick and faced with a tamped-in refractory.

A ladle must be brought to a red heat before tapping metal into it. This can be done by placing it on bricks above the furnace exhaust hole during the melting. Larger ladles, which would be cumbersome to heat in this manner, must be heated with a ladle heater.

Care of Crucibles

The prices of crucibles have skyrocketed since 1970, therefore it is a good idea to take good care of them to reduce costs and get the maximum life from them.

Store crucibles in dry places, especially those made of graphite. Do not let them become damp by placing them on concrete floors or on the ground. Graphite crucibles should always be brought up to their operating temperature slowly. Also, never put a cold crucible in a hot furnace or turn the burner flame directly onto a cold crucible. Fire up the furnace for a few minutes. Then shut it off and place the crucible in so that it warms gradually from the residual heat of the furnace, or, the cold crucible can be inverted over the sight hole of the furnace if it is already operating. This procedure will warm and dry the crucible properly and gradually. None of these precautions are necessary with silicon carbide crucibles because they do not absorb moisture and are more resistant to thermal shock.

Cold chunks of metal should never be jammed into a crucible before firing it up. The expansion of the metal could crack the crucible.

QUICK»TIP Lifting the crucible out of the furnace and pouring the molten metal is the most critical and dangerous operation of metalcasting. The hobbyist must wear heavy leather gloves, leather shoes, and a face shield. He should also wear a heavy leather or canvas leggings, preferably. Foundry suppliers offer a variety of safety equipment of this type, and it is the best investment that can be made by the home shop metalcaster.

Plece pieces loosely with plenty of room for expansion. You should never let a molten charge of metal solidify in a crucible. Pour out elmost all of the melted charge before it solidifies. The remelting of e solidified cbarge may cause the crucible to crack from the expansion of the metal.

Never use e crucible wbich sbows any signs of cracking. It could break while lifting or pouring.

A crucible sbould never be filled excessively. The level of molten metal should never exceed about 4/5 of the maximum capacity of the crucible. Special tongs should be used to lift and pour. No makeshift equipment should ever be used by any metelcester.

Tongs

Crucible tongs are made in several designs and styles. They can be purcbased from foundry suppliers, or you can make your own based on the designs sbown in Figure 6.4. The arc-shaped end which grips the sides of the crucible must fit its contour firmly and securely. Therefore, e different size tong will be required for each size of crucible. Tbe L-sbaped style shown in Figure 6.4 seems to be sefe, although this kind is more difficult to construct.

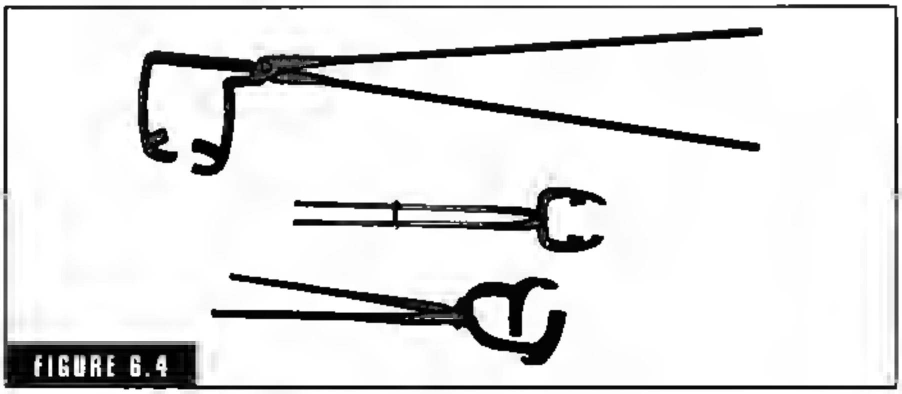

FIGURE 6.4

Commercial tongs for lifting and handling a small crucible.

Table 6.2

Color	Temperature°F.
Faint red	900
Blood red	1050
Dark cherry red	1150
Medium cherry red	1250
Cherry red	1450
Bright red	1550
Orange	1700
Yellow	1850
Light yellow	2100
White	2300

Temperature Determinations

Many hobbyists are tempted to judge the proper pouring temperatures of their metals by the appearance of the melt alone. Tbis procedure can be used, but it is not recommended.

The *approximote* temperature inside the furnace or crucible can be estimated by looking through the sight hole in the lid and comparing the color with the scale in Table 6.2.

A problem with the use of any color chart is the subjective interpretation we all give to color. The amount and type of illumination also affects color interpretation: wbat appears bright red in a home shop corner, or on a dull, dark day, may well appear as dull red in a brightly lit environment. Changing the light type to bright fluorescents can also change color interpretation, because standard fluorescent bulbs give off a yellowish-green light that can make metal seem hotter than it is.

Optical Pyrometer

How does ona measure the temperature of molten metals far above the range of thermometers? One instrument for such use is the optical pyrometer, but it costs a couple hundred dollars so it is often beyond the reach of typical hobbyists. The optical pyrometer depends on comparing and matching the color of a glowing filament with the color of the object being measured. The electrical current is observed and adjusted through the filament until its image disappears wben viewed against the background of the furnace or crucible interior. Tbe filament and object are then at the same temperature. It can be read from a cali-

bratad dial on the instrument. Readings can be taken very rapidly and at some distance from the furnace.

Thermocouple Pyrometer

For measuring high temperatures, a thermocouple pyrometer is used. Its operation works on the principle that wben the junction of two dissimilar metals is heated, an electrical voltage is generated. This voltage can be measured in an external circuit by a device such as a meter or potentiometer. The voltages (or currents) generated are quite small but they are measurable with simple equipmant.

Connect a tharmocouple (the two pieces of dissimilar matal in tha form of a pair of wires) to a simple direct current meter. The current and the meter reading depend not only on the temperatura of the junction, but also on the resistance of tha matar and wires; tharefore, a simple instrument of this kind does not maasura temperature diractly. It is calibrated by comparing the reading at known tamparaturas.

Buy a 0-50 milliamp direct current meter from an electronic or surplus store. It should have a scale length of at least 2 inches for accuracy and be readable to 1 milliamp or better.

Also obtain a chromel-alumel thermocouple made of 8- to 14-gauge wire. It should be equipped with caramic insulators and with a minimum length of at least 18 inches. Tban connect tha two leads of the thermocouple through the intermediate heavy copper or brass wira (Figura 6.5). Tha connection from the tharmocouple wire to the lead

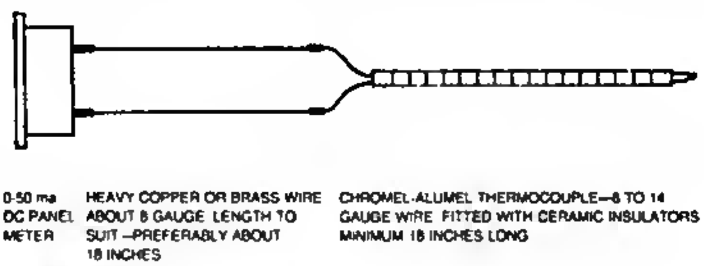

FIGURE 6.5

Schematic of a simple thermocouple pyrometer.

wires should be brazed or silver soldered, although good mechanical connectors should work. Tight, secure electrical connections are essential for stable readings of the instrument. The lengths of the intermediate lead wires can be made to suit, but about 18 to 24 inches should suffice for readings in a small furnace.

The thermocouple pyrometer is now ready for calibration. Should the meter needle deflect downscale wben the tip of the thermocouple is heated, reverse the leads to the meter. The meter should read zero when the thermocouple is at room temperature. If not, adjust it to zero with the small screw below the face of the meter.

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CHAPTER

7

Casting Small Items

The amount of detail raquirad on small surfacas is tha primary difference between cesting smallar itams, such as jewelry, belt buckles, and othar decorativa or craft items and larga, utilitarian items. When cesting a large section of iron or steal, or even brass or bronze, less detail ellows for smoother, less detailed surfaces, and larger patterns usually do not require tha axtramaly fine details that sometime occurs in smallar, more ornata castings.

Mucb of the fine detailing can be produced with the refractory materiel, which allows for good detailing with as smooth as possibla finish, but some is better handled in tha way tha mold is designed.

Lost wax and investmant casting are excallent for extreme detail and for fancy shepes. Choosing batween sand casting and investment or lost wax casting depends on wbat you bave for a pattern and how claan a final finisb you must produce. Lost wax can, with the right investment, reproduce fingerprint detail and reduce macbining to a minimum. Sand cesting does fairly well too, but is less forgiving to tha novice. Ramming that sand and getting the right consistency is an art that takas tima to learn. If you maka a wax copy of your original, or carva an original out of wax, you can add all kinds of detail, lettering,

and undercuts in the wax before you make the rubber mold to produce tha wax patterns. On the first pour, you can sprue together as many patterns as you can melt metal. Tha bard work is in the single original.

RTV silicon mold rubber comas in 5 gallon quantities and is costly. Wax is cheap. Go wax for detail, but remember, there are fewer steps in sand.

Investment Casting Basics

Precision casting, sucb as that used to maka jewelry and small modal parts, was first developed to cast precision dental parts. Othar industries recognized the usefulness and climbed right on the wagon, so the process is very popular now.

Thare are fiva assantial staps to precision investment casting:

1. Maka the wax pattarn—this is expendable before casting, or "lost."
2. Case or *invest* the pattern in a refractory material that can stand high heat and reproduce every detail in tha pattern as tha mold forms.
3. Burn out tha pattern, laaving a nagativa mold insida the invastmant material.
4. Cast by filling the mold with metal.
5. Destroy the mold to recover the casting.

It sounds aasy, and in most aspacts, it is easy, but thera are datails to ba considered that maka for a mora, or less, parfect job.

Making the Pattern

This step is the most involved and difficult, because the whole idea is to maka a complax pattern that reproduces perfectly in ravarse (negative) in the investment material. There are a number of kinds of waxes, some for carving and some for molding, each with different features. The only way to decide on a wax for a particular job is to experiment to see wbich does best in your hands. Blended waxes include waxes like beeswax (usually wbite), carnuba, ozenite, and synthetic waxes; resins like sbellac, rosin, balsam, and other tree saps; and fillers like talc, starch, cbalk, pumice, wood flour (fine sawdust), and others.

You need to make or buy a wax that lets you work it as you wisb, wbether you're carving or molding by band, or combining the procadures. Carving waxas are readily available in tubes, rods, blocks, and sheets as thick or as thin as you need. Hardness is variable, but most

carving wax is not easily bent or finger-shaped. Modeling wax is softer and is easily formed by hand.

Melting wax is a simple process, but needs some care, because liquid and near liquid waxes may reach a flash point and catch fire explosively. Melting wax should be done in a double-boiler arrangement, never in a single pan. This prevents really bad overheating (as long as you keep water in the lower pan). Speaking of water, whenever you're heating wax, keep a pan of cool or cold water nearby. A fast douse with the water can reduce burning considerably, should some hot wax splash on you.

Keep melted wax away from open flames (although an open flame can be used to melt wax enough to weld blocks together). Never set a solid pot of wax on a burner. Wax expands as it heats, and the cap, or top, will heat and melt last, creating a pressure build-up that can be dangerous.

Processes and tools used to work the wax depend on the size and shape of the mold needed: if you're working gold or silver, it's unlikely massive molds will be made, but for fine brass or other castings, larger molds may be needed. It's beyond the province of this book to provide art instruction, but see the appendix for a couple of books that provide lots of model-making information. You will do lots of filing with coarse-toothed files, and eventually will find you need to make many of your own shaping tools, but that process itself becomes a lot of fun, once you decide what you need to do and how best to modify a tool to do a better job.

Carving wax may also be shaped on a lathe, with a soldering iron, or with wood carving tools. Smoothing is done with fine files, or even a nylon stocking or piece of paper towel. Don't use materials like sandpaper or steel wool (no matter how fine) that can leave grit or debris stuck in the wax.

Special wax pens are available for various kinds of shaping uses, which saves the overheating problem common with soldering irons or wood burning tools. If you've already got a soldering iron or wood burning tool on hand, then you can mount a dimmer switch (potentiometer) into a small box, run a cord to a plug, and place the potentiometer in the circuit between the plug and an outlet on your box. Mark the dial around the potentiometer so you can judge heating levels.

Burn-Out Oven

Investment casting demands a burn-out oven of some type. The oven is used to burn out the wax after the investment is poured. You can

buy such an oven, or you can make your own. Temperatures abova 1250 F. are not needed heceuse thet's the ebsolute veporization point for the wax. At temperetures ehove thet, the gypsum hindar in most investments tends towards instability, creating problems during and after casting of the metal (the released sulfur raally massas up silver by darkening it, but there's often also a savere loss of detail, wbicb dafaats tha entira point of this kind of metalcasting). Firebrick and refractory cement are essential ingredients of any kiln or oven. After maating that requirement, you can decide bow fancy to get. You mey choose to work with a gas fuel set-up (propana or MAPP, or MAPP and acetylana) with nichroma beating alemants and a pyrometer and control switcb. You mey elso huy an oven directly from e supplier. After the burn-out (oven) kilns, add the following:

The most important considerations with a burn-out kiln are not only temperature but also oxygen once the sprue or pouring hesin is wbita and frea from carbon deposit laft by the wax. Tbis is no guarantee that the mold is clean and frea from carhon daposits inside the mold cavity. If it is not completely free of carbon, the surface of the casting will look lika fina oranga peel—rough, not smooth. Tberefore, sufficiant secondary oxygen must come into tha combustion chamber in order to reduce the carhon to CO and CO_2.

Electric kilns are, for the most part, not designed for other than e neutral etmosphere, giving you little control. With the gas-fired kiln (i.a., catenary arch kiln fired against bag walls with positive downdraft circuletion), you can control the combusion cbamber to either oxidation or reducing conditions. The only way to he sure that the carhon left by the wax bas been completely elimineted from the cevity (i.e., $C + 0 = CO\ CO_2$) is by inserting a copper tube (¼" tubing) with a sbort dog-leg on one end into the pouring basin of the funnel down mold in the kiln. You then draw some air out of the mold into your mouth. The beat dissipates through the four feet of tubing, wbat you draw in is cold or barely warm wben it reacbes your mouth. If you tasta wax in your mouth the mold is not complately free of wax/carbon. The mold sbould ba left in tha kiln until tha copper-tube tast has ebsolutely no taste wbatsoever when you draw on the tube with your mouth. At this point, you beve e completely clean cevity, free of wax/carbon and it can be poured without risk or orange-peel surface. This procedure is tha only positiva tast for a clean mold burn-out. Relying on tha tima and temperature methods is risky if you need e clean mold hurn-out.

After a mold is ready to be placed into kiln to be dewaxed and calcined, it must first be placed underwater in a suitable container and weighted down. Weight the mold to keep it submerged. Leave it underwater until it stops bubbling and is completely saturated. This puts everything into a state of equalibrium. The mold is now placed in the kiln—basin down on kiln furniture. Tbe kiln is then fired slowly. The mold should not have random wet ad dry areas that can cause uneven expansion. Always remember to soak the mold to equalibrium when is being dewaxed so that the burn-out starts on a level playing field.

Super Simple Set Up

The simplest burn-out oven is one made of firebrick and heated with a torch. Simply place two firebricks on a flat surface, stand two bricks at each side, and two on top, with a notch cut in the back side of one side brick, and a hole cut in the top. The 2-inch square notcb in the side brick lets heat be applied, while the 2-inch square upper notch provides a vent that lets gasses flow out. Use an oxy-MAPP or oxy-acetylene torcb to provide heat. Aim for a simple gauge to tell when tho burn-out temperature is right. Make a small ball of clay and stick an 8- or 10-penny aluminum nail in the ball. Set it in the oven. When the nail bends, the temperature is about 1200 F., right about wbere you need to be.

Electrical Burn-Out Ovens

A nichrome-heated burn-out oven (Figure 7.1), with a pyrometer and a control switch, is more complex but relatively easy for any person handy enough to melt metal to make. With a 1000-watt nichrome coil, you'll have an oven capable of producing well over 1500 F. You can use a 660-watt element if you can accept slower burn-out times. Nichrome beated elements are readily available at electrical supply stores.

As the burn-out progresses, you'll want to avoid the room as much as possible. Vaporizing wax doesn't smell good, and in beavy concentrations, it's dangerous. Good ventilation is imperative. Always turn off the oven before you cbeck the mold.

A nichrome-heated oven can be built in your own sbop with little more than a cbisel, a hacksaw, a couple of metal clamps, and other readily available tools. You may want to get right angle bends in the metal—26 gauge mild steel sheet—done commercially, but you can

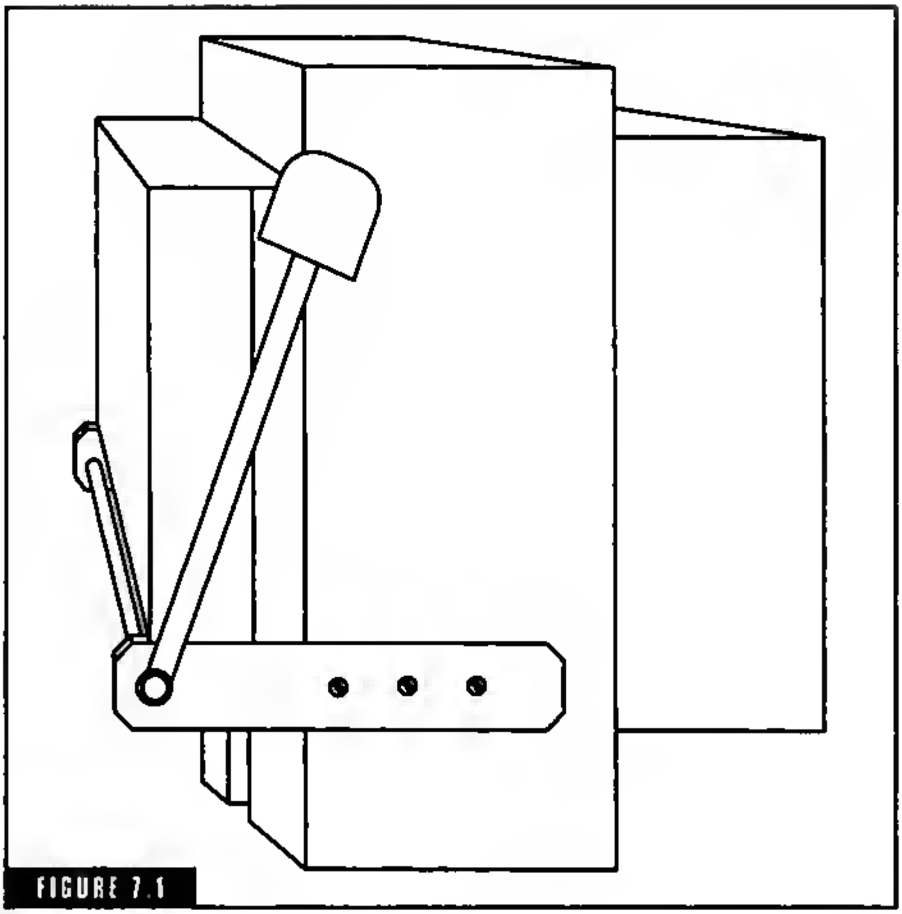

FIGURE 7.1

Front side view.

bend it yoursalf using a couple of pair of metal bending clamps. These clamps bave plates about 2½ to 3 inches wide that make gatting clean corners a lot easier. Most parts can be found with little trouble.

You need six firebricks, type classified at 2400 F. Refractory cement is needed, too, and a pint is probably enough. The beating element must bave a 110-volt classification; a power control, Type CRS, rated for 1000 watts; and a pyrometer with a temperature scale that reads over 1500 F. (to 1800 F. is preferable).

The oven door is pivoted on a rod and closes with a drop bar. See Figure 7.2 for details and dimensions. The sheetmetal is cut to size, using aviation cutting sbears. Fold, or have the parts folded. Make sure the bricks are sized to fit the three walls, floor, and top. Cut two bricks to 5½ inch langths, and cut one brick exactly in half. The remaining

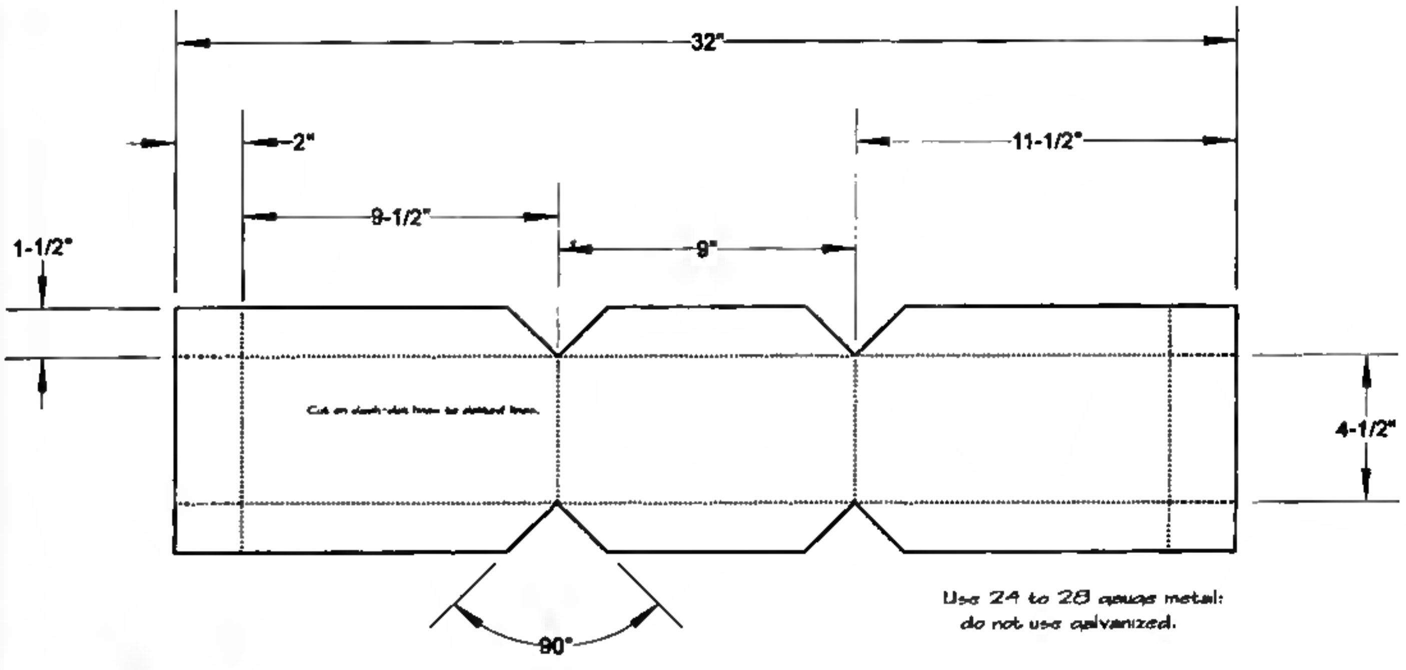

FIGURE 7.2

Metal skin layout.

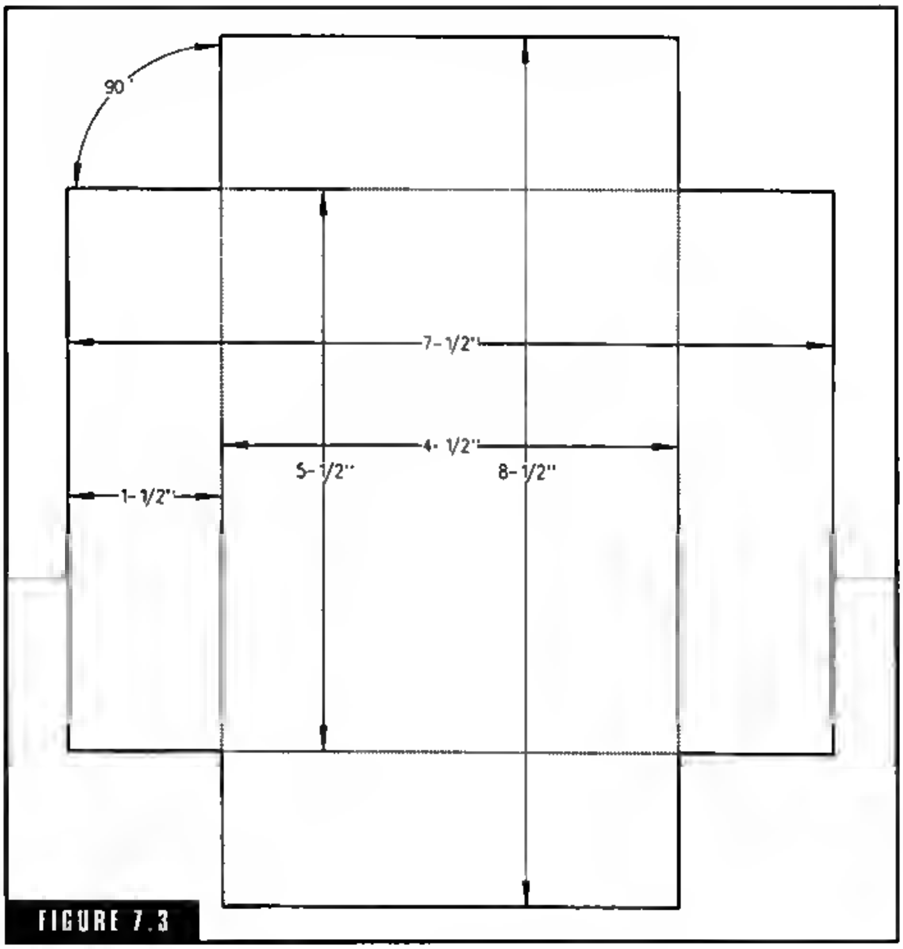

FIGURE 7.3

Door covering.

two full-length bricks make the top and bottom of the oven. Cut the firebrick with a backsaw (a 12 tooth per incb blade is fine, but 18 tpi works well, too). Now, place the two balf bricks down, and carefully gouge them out for the nichrome heating element. Tbe job can be done with a wood chisel of the proper width—about ¼-incb wide. The gouge sbould be just deep enough to bold the nichrome element and wide enough to fit it snugly (cbeck actual measurements before gouging).

Firebricks are very soft, so use care in handling them. Rough bandling guarantees scratches, gouges, and probably breaks. The nichrome coil must be stretched to fit the gouged pathway, and the ends of the wire sbould be completely straightened.

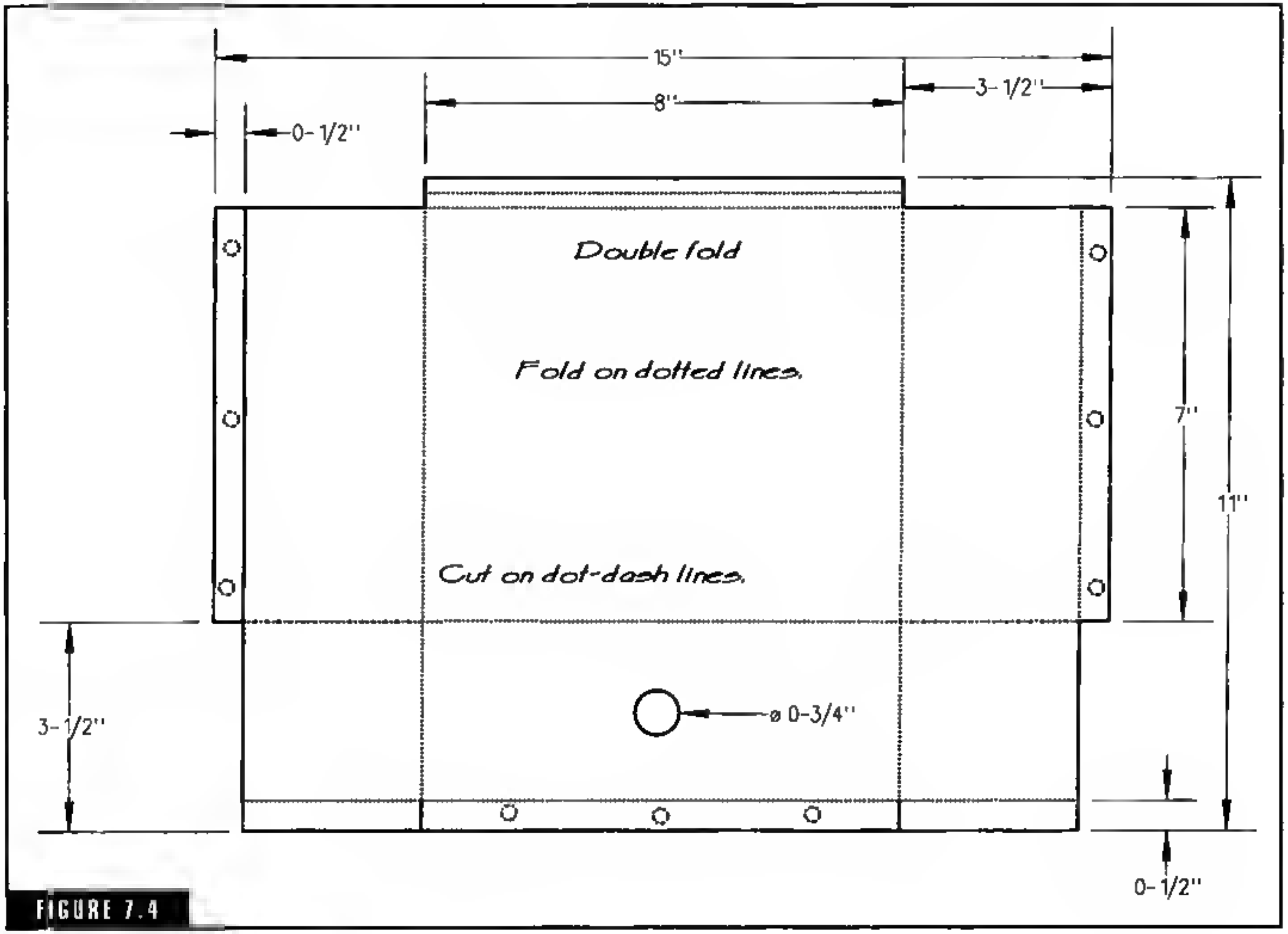

FIGURE 7.4

Back sheetmetal layout.

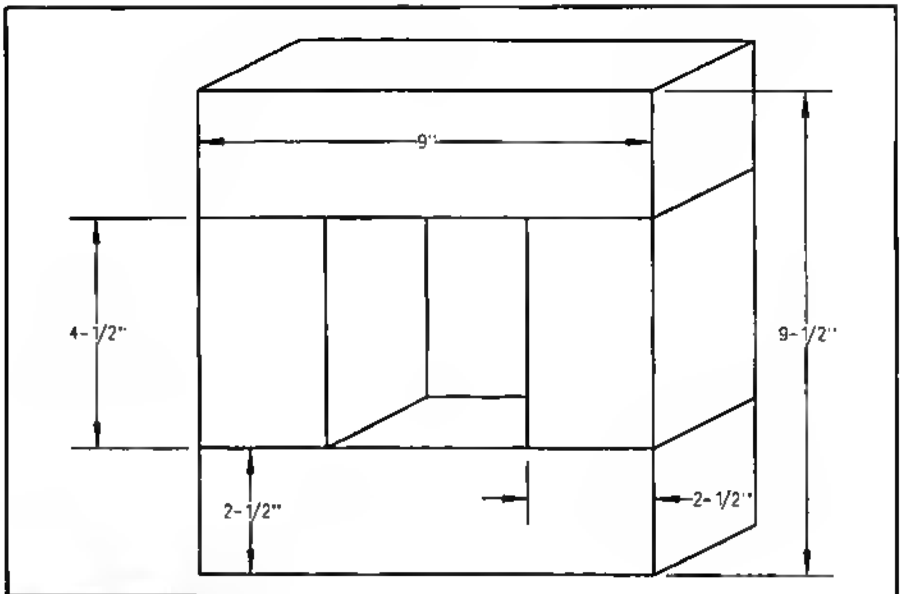

FIGURE 7.5

Main chamber brick layout.

To hold the nichrome in place until it takes its initial set, use staples wide enough to span the gouge and hold the nichrome in plece: the nichrome is cut in half (es exectly es possible), and placed. If you beve more electricel experience, you can temporarily wire power to the nichrome so thet it beets and takes its permanent set while lying outside the oven. This is the easiest, but is dangerous for those who aren't used to working with electricity.

Take several 16-penny neils and cut the beads off. Drill slightly undersized holes in the assembled oven bricks. Set the floor brick down, plece the side balf bricks on that (making sure the open end of the nichrome loops point in the same direction), and then place the top brick over that. Drill ¼-incb holes through the top brick down into the side bricks, making sure they're positioned to miss the beating elements. Push fit the heedless nails: you mey heve to drive them, but do so with greet care beceuse the brick is fragile. Now, turn the essembly over and repeat the process with the bottom.

Take the 5½ inch bricks and fit them into the ends of the oven, forming e rebbet all the way around so that the bricks fit snugly into plece. One brick is part of the door, and one is part of the back of the unit. Size the rabbet to suit your exact dimensions once the top, bot-

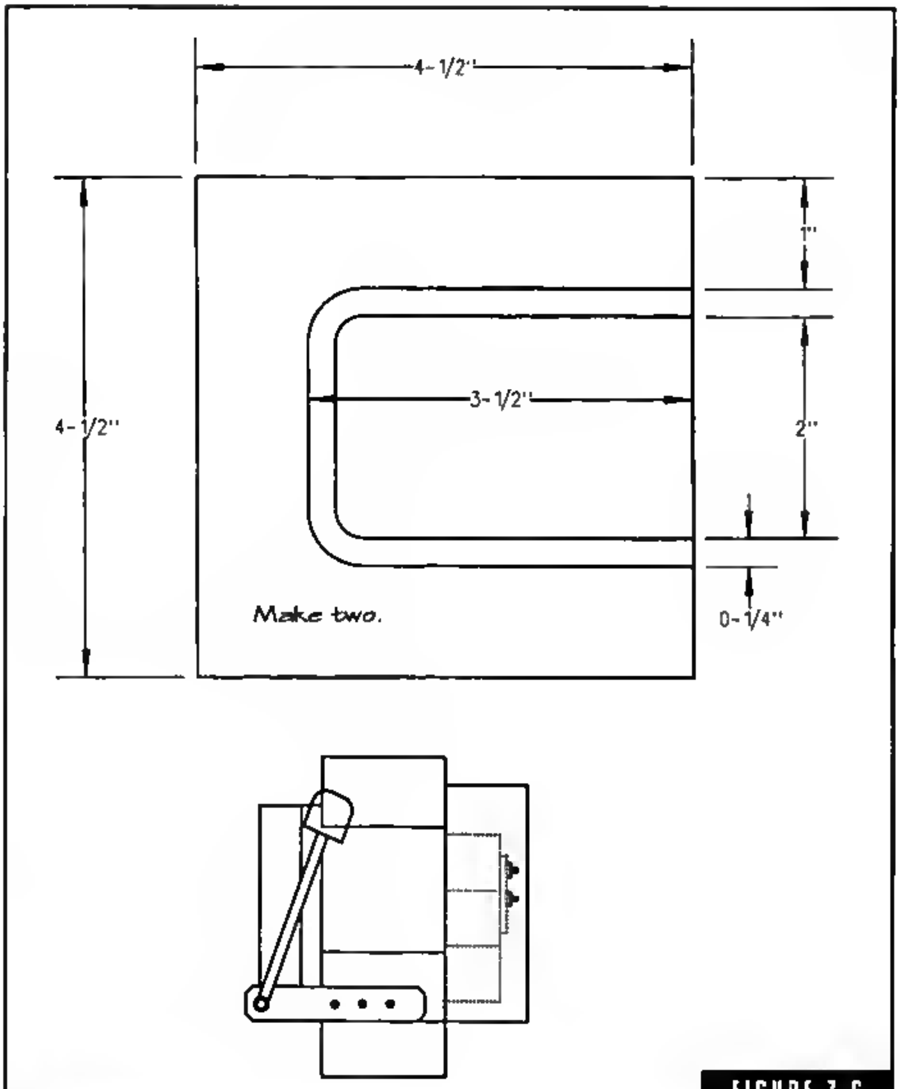

FIGURE 7.6

Side brick grooves.

tom, and sides are essembled and pinned in plece. The rebbets should be ebout ¼-inch deep and ¼-inch wide; this mey require edjustment.

Form up the metel case using sheetmetal screws. Top, bottom, all four sides.

Slide the firebrick assembly into the case. Attach hinges. The simplest hinge is nothing more than a steel rod through plates on door and oven, two on eech, et the base of the unit, so that the door pivots

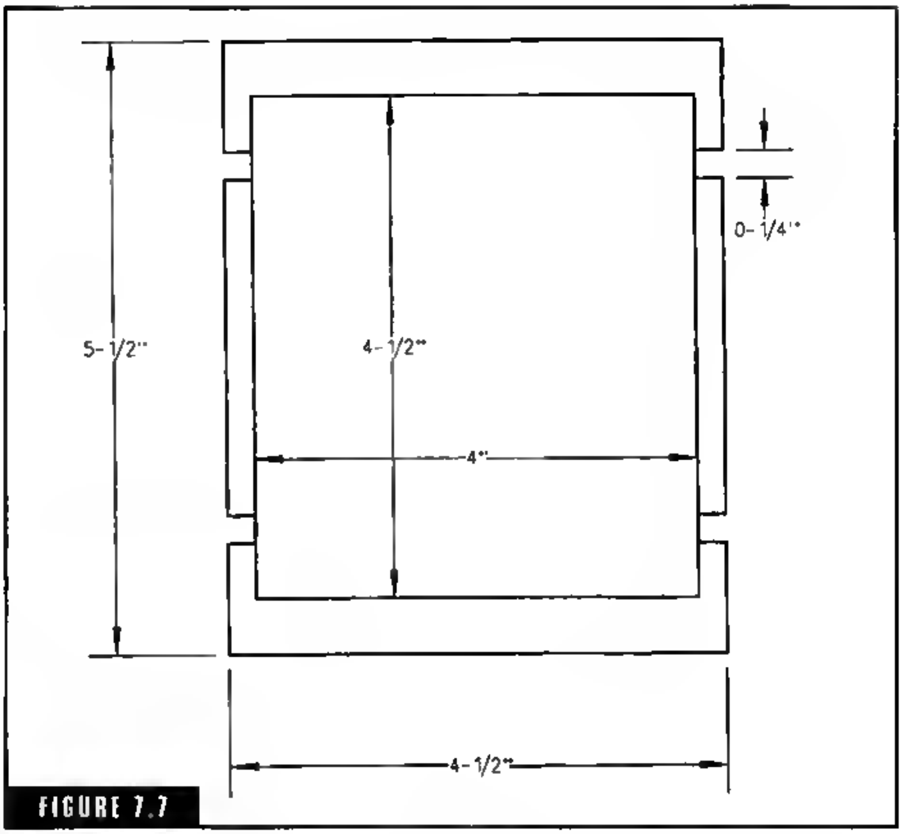

FIGURE 7.7

Back interior.

upward to close. Holes in the plates allow the door to rotete down and out of its opening. Years ego, e friend of mine built some wood stoves that use a wood-handled knob that also works exceptionally well for this oven. The base of the door is bolted to a couple of steel flets, through which the hinge rod runs. Thet rod is bent upwards and out from the furnace a bit; it hes e 1½-inch diameter, 2½-inch long wood knob pleced on the end. Pulling it to the operetor opens the door, pushing it up closes the door, and the knob falls far enough aheed of the door so that its modest weight, and the weight of the rod, serve to hold the door closed. If thet isn't sufficient, edd e counter-weight at the head of the rod, under the wooden handle and drill the handle to fit over it.

With the drawer ready, and the sliced brick for the wiring ready, use furnece cement to form fillets et all corner joints inside the kiln.

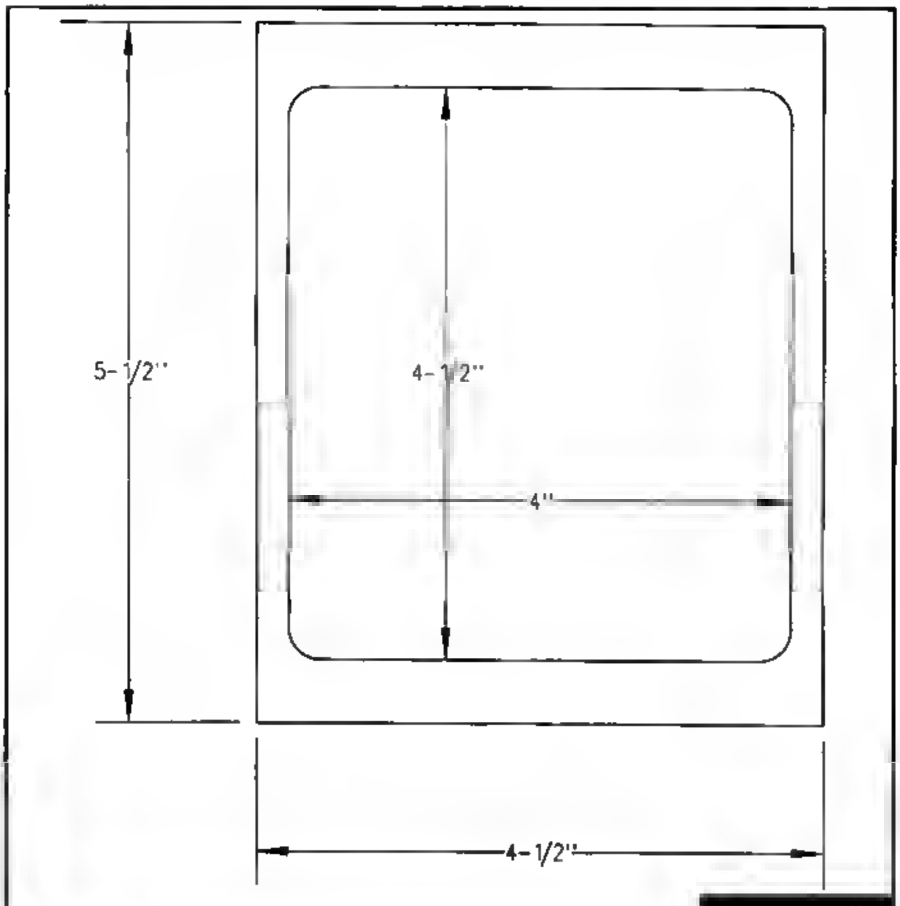

FIGURE 7.8

Front door interior.

See Figures 7 for further details.

Clean Burn-Outs

The cleanest burn-out results when you start the work with the sprue hole down. The molten wax then flows out of the sprue hole onto the oven floor. At the point when the wax stops flowing, carefully turn the flask over so the sprue hole is on the top. Gasses escape more efficiently this way. When the edges of the sprue show white, then burn-out is done.

At this point, it is time to pour metal; the best results are had when the investment is still warm from burn-out.

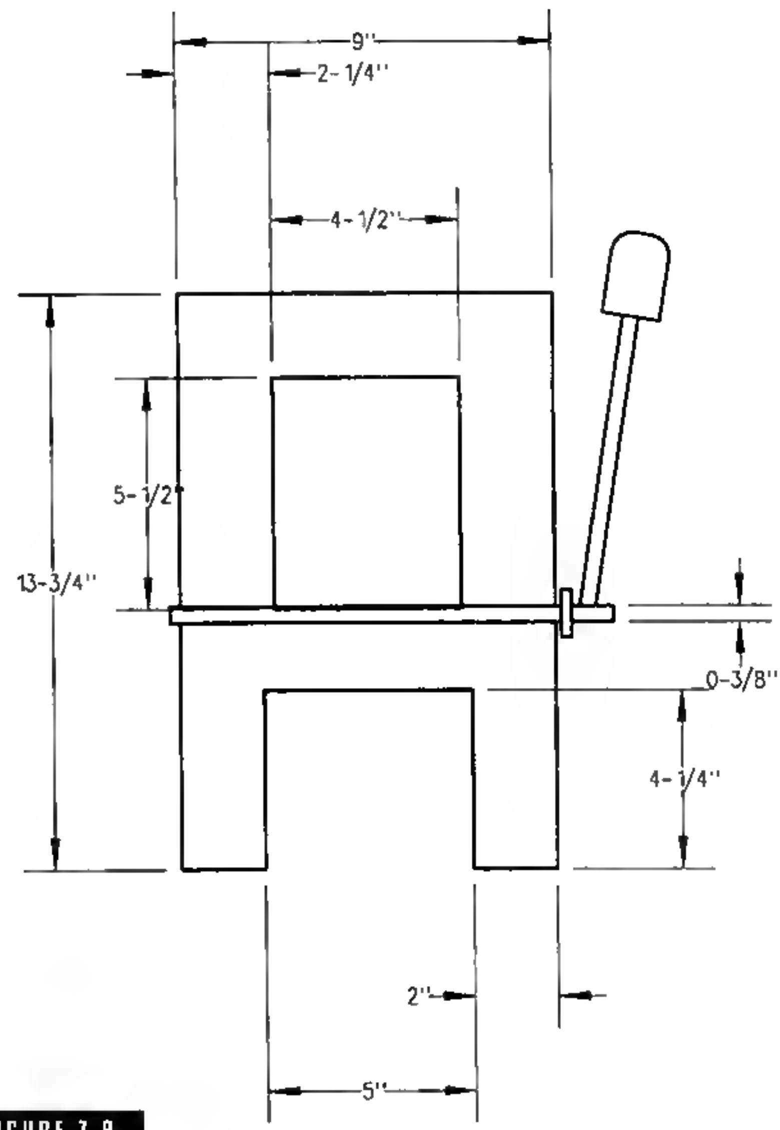

FIGURE 7.9

Front view.

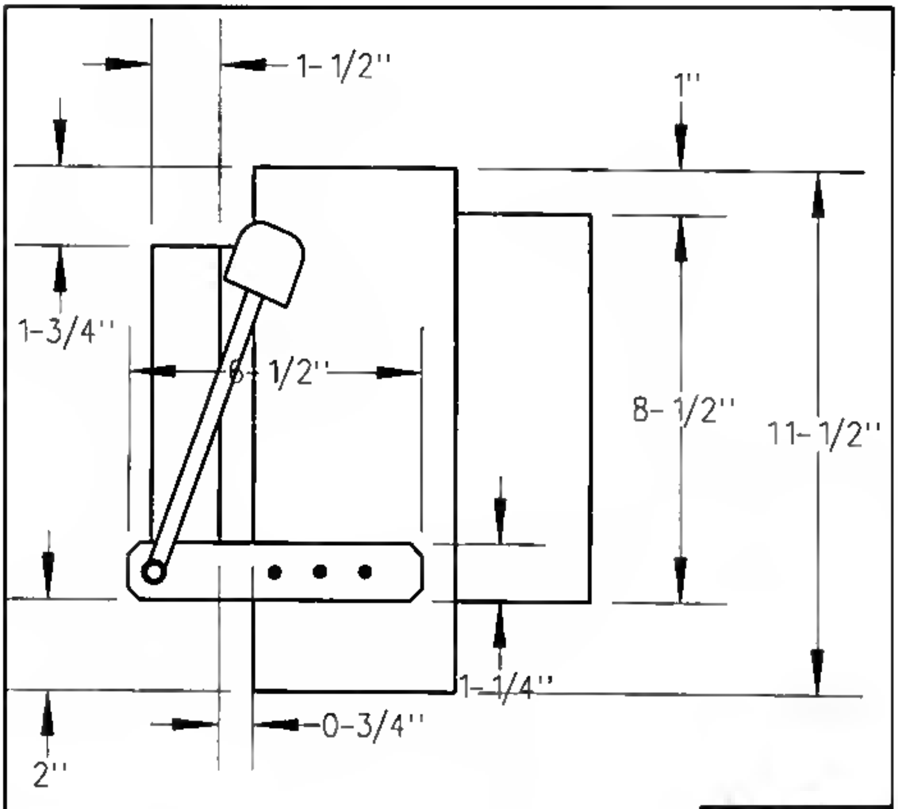

FIGURE 7.10

Oven side view.

Investments

Investments for fine detail are made of gypsum (hydrated calcium sulfate, a white mineral). It makes up as much as 40 percent of the mix. Silica is also used; it is white or colorless and sometimes known as quartz. It cushions the mold and allows for expansion and contraction as the mold heats and cools during burn-out and cool-down. *Cristobalite* is a form of very pure silica formed by heating silica to temperatures up around 3000 F. Other chemicals may be used, including wetting agents, to let the investment flow more readily over the model. Some ingredients may change the setting time of the investment or reduce air bubbles in the mix. Generally, gold, silver, bronze, and most other metals need a standard investment, while platinum needs a high-temperature investment.

The silica used in investments is of such a fine, powdery texture that it is recommended that proper dust masks be worn while using the dry material.

The gypsum used is hygroscopic: it is so thoroughly dried thet it actively seeks to draw water from the air. The material must be kept in sealed plastic bags. Buy in quantities that will be used in a few months to prevent contamination.

Investment can be bought through most jewelry suppliers, and may be found through some commercial metalcasters.

Investing

Start by cbecking the model for debris, dust, or other dirt. Check the fit between the flask and the base to be sure it is watertigbt. Seal with wax if it isn't. Paint the model with a wetting agent to reduce the possibility of air bubble.

Part of the fun, for many of us, in casting is the mess: investing is a messy process, and some clean-up time must be figured into the job, no matter how careful you are.

As e side note, if you bave investment left over, discard it properly. Pouring it down the drain is going to result in a call to the plumber, because the material hardens in the pipes. When working with wax, equipment made of rubber—bowls, spatulas, and similar items—work best and clean easiest.

Investments not otherwise marked bave a working time of 9½ minutes. Watch the clock, because taking too sbort a time to mix the investment means water may settle out wben the investment is in place, leeving bubble trails around the mold pattern. Mixing for too long means the investment will have partially set up and won't be liquid enough to flow properly everywhere it's needed.

Weter et 72 F. is used at about 38 to 40 parts to 100 parts of powder, by weight. Add powder to the water and make sure the mixing is complete.

A vacuum machine is used to remove bubbles from the mix after it is poured into the flask. Leave about a 2-inch space at the top of the flask for the expansion that bappens under vecuum. Without a vacuum machine, use vibration to settle the mix and remove air bubbles.

Make an eccentric cam to fit into an electric drill, and heve thet turn against e stand that holds the flesk.

The *shell method* is probahly easiest, hecause no speciel gear is needed. Mix investment in small amounts, no more than e quarter cup et e time for jewelry models, and paint the investment onto the model with a soft hrush. Make sure to get into the hard-to-reech spots. Sprinkle the peinted model with dry investment powder, and repeet the process. Tbe first layer gives the surfece quality of your casting, so it is exceptionally important. Once the two leyers are dry, surround the entire package with investment. On this step, you can forget ebout huhhles, heceuse any present beve no effect on the final casting.

Once the investment is complete, the mold goes to the hurn-out oven.

We're only covering grevity cesting, hut lots of people use centrifugal force to make sure material is in every cavity in the mold. Extre mechinery to spin the mold is needed. If you evoid thin, lecy arees, then gravity casting works fine. If you want thin lecy areas, then get e centrifugel cesting mechine with e coiled-spring drive unit.

The flesk can he quencbed in e bucket of weter as soon es it is no longer red hot. Most euthorities say use e cbeep plastic bucket, and hold the flesk ehove the hottom for the first few uses. After the third or so quenching, e leyer of silted investment will heve huilt up on the bottom of the bucket, and you bave to worry less about setting the flask down and heving it melt through. The investment is caustic enough to rot out any metal hucket quickly, so plestic is preferred. The bucket will fill with investment over time and must then he discarded and repleced, heceuse it's just ehout impossihle to clean the semi-hard investment out of the hucket. Discarded drywall huckets from construction sites make excellent recycled quenching huckets.

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CHAPTER

8

Metallurgical Properties of Cast Metals

Pure metals are rarely used for making castings. Tbe proparties of pura metals can be improvad with respect to fluidity, melting point, strength, and hardness by tha addition of alloying elements. Metellurgy bes resulted in the development of certein standard casting elloys wbicb heve ideel properties for given epplications, and the hobby matalcaster will find that the use of these meterials yields fevorable results.

A particular metel or elloy is chosen for e given cesting dictated by a number of fectors such es required strength, surfece finisb desirad, cost, ductility, and ease of machining and casting. Cast iron does heve certein deficiencies, but its low cost offsets the disadvanteges.

Pupular Allnys

Many aluminum alloys are used for metalcasting. Tha most versatile are the aluminum-silicon alloys, wbicb combine good castebility with excellent corrosion rasistance and bigh strength.

Aluminum

Aluminum alloys cast very easily, and the beginner is encouraged to experiment with aluminum casting first before graduating to the more difficult-to-handle brasses and bronzes. Basically the techniques are the same in all cases, but aluminum alloys are eesier to handle and melt.

Scrap eluminum works well if you carefully pick out only screp castings such as gear cases, cylinder heads, mechine parts, etc. Avoid pistons and connecting rods because they are elloyed with other elements whicb mey make the material less suitable. Avoid wrought or structural aluminum scrap completely beceuse it is not alloyed for casting purposes and will give poor results.

Segregating aluminum and megnesium alloys is not alweys done well by screp dealers. Do not mix magnesium with aluminum screp beceuse the eccidental melting of magnesium may lead to e fire. Once ignited, megnesium cannot be extinguished. If it should ignite, cover it with sand to slow the burning and let it go. Never epply weter to burning magnesium—only dry sand. Sometimes megnesium alloys can be identified by sight. It is grayer and less dense than eluminum. If there is any doubt, apply a drop of 1 percent silver nitrate solution to the filed surface of the metal. A black stain is produced immediately if the metal is magnesium. Aluminum and its alloys remain unchanged.

QUICK»TIP **Many aluminum auto and light truck wheels get junked annually, and most of those are about 356 T6 alloy. This is a nicely castable alloy, strong, and with other good features—ductility, resistance to cracking—that make it decent for wheel use. It is particularly important when using aluminum alloy wheels to check each wheel for the possibility of its being magnesium, as tons of that flammable metal are also used for wheels.**

Silicon Bronze

Silicon bronze casting alloys heve grown in popularity. They heve excellent casting properties with strength approaching that of low-carbon steel and good corrosion resistance. Silicon bronze alloys contain ebout 95 percent copper and 4 to 5 percent silicon. They also contain minor amounts of manganese and zinc.

Silicon bronze has the best combinetion of properties that appeal to the amateur metalcaster of all reedily evailable copper-based alloys. It is inexpensive and can be repeatedly remelted without changing composition. Silicon bronze is evaileble under the trade names Herculoy and Everdur.

Red Brass

Red brass can be considered as either a brass or a bronze. The composition varies, but the typical red brass contains about 85 percent copper and 5 percent each of tin, lead, and zinc. Red brasses are among the most widely used of all copper-based casting alloys. Tbey bave numerous uses in the production of pipe, valves, fittings, pump housings, and plumbing fixtures. They also offer an excellent combination of resistance to corrosion, bigh strength, and casting properties.

Bronze

Bronze is not an alloy of definite composition. It is an alloy of copper and tin. It may also contain small amounts of other elements. Other bronzes contain relatively little tin, such as manganese bronze, and other alloys contain no tin at all, sucb as aluminum bronze (copper-aluminum) and silicon bronze (copper-silicon). Some alloys are called bronzes but in reality are brasses, sucb as architectural bronze (copper-zinc-lead) and commercial bronze (90 percent copper, 10 percent zinc).

The term *bronze* used without qualification usually means tin-bronze. Wben tin is added to copper it increases its bardness and strength. Zinc is sometimes added in small amounts to improve the casting properties. Lead improves the macbining qualities. Tin bronzes contain about 87 to 90 percent copper, 6 to 10 percent tin, and 2 to 4 percent zinc. If lead is added to improve machining, it will usually be present in about 1 percent. The alloy will then be referred to as a *leaded tin bronze*. Tin bronzes have excellent casting properties as well as good mechanical strength and ductility. Tin bronzes do tend to be a little more expensive than yellow brasses wbicb contains no tin.

Bronwite

Bronwite is a patented alloy manufactured by ASARCO. Originally it was developed to replace nickel silver alloys and to avoid the high cost and availability problems involved with nickel. Bronwite contains 59 percent copper, 20 percent zinc, 20 percent manganese, and 1 percent aluminum. With respect to color, corrosion resistance, strength, ductility, and bardness it is the equivalent of nickel silver, but it's easier to cast because of the low melting temperature of 1550 F. Bronwite can be polished to a very bigb luster. Parts originally made

of nickel need not be plated if they are made of Bronwite. Also, its resistance to tarnishing is just as good as nickel.

Zinc

Tbe most common alloys of zinc are the Zamak alloys which contain about 95 percent zinc, with 4 to 5 percent aluminum, and occasionally slight edditions of copper and magnesium. Zinc die casting alloys have good strength and cesting properties, but they lack corrosion resistance and ductility. The only edvantege is the low melting temperature, wbich reduces the high tempereture capebilities required for the melting furnece.

Undesirable Alloys

Many alloys used during metelcasting should be avoided by the heginning metalcaster in the home hobby shop.

Manganese Bronze

A favorite cesting elloy for parts requiring high strength and resistance to corrosion is manganese bronze. Manganese hronze compositions vary quite e bit, depending upon the strength characteristics desired, but typical compositions are around 60 percent copper and 25 to 36 percent zinc, together with small amounts of iron, eluminum, and manganese.

Because manganese bronze is not an easy material to cest, the beginning metalcaster should avoid it.

Aluminum Bronze

Aluminum bronze has enormous strength, far exceeding thet of mild steel. In addition, it can he heet treeted to improve its strength. It has a narrow solidification range and high shrinkage upon solidificetion, making it an extremely difficult material to cast.

Brass

Bress is reedily available in scrap form, which would appear to make it an ettrective choice for the amateur. However, brass is not easy materiel to cast and the bobbyist is likely to experience some difficulties with it, especially et first.

Brass does not danote a specific composition of material. It is a class of alloy. Brass is an alloy of copper and zinc containing more than 50 percent coppar. It may also contain minor amounts of other alloying materials. Yellow brass ordinarily contains 65 parcent copper and 35 parcent zinc. It bas a pleasing yellow color. It also polishes well.

The term *brass* usad without qualification usually means yallow brass. It contains copper and zinc. Othar compositions ara also used for specific applications in industry. Scrap brass contains a variety of diffarant compositions mixed indiscriminataly. The metalcaster using scrap brass will find that casting properties vary from melt to malt.

When brass is brought to its melting tamperature, zinc distills out. It also burns above the molten alloy. This problem can ba allaviatad by providing a protactive cover of flux ovar the melt.

Scrap Versus Virgin Alloys

Scrap brass and bronza are readily available at scrap metal dealers. Tbay ara oftan at pricas about half that of commercial alloy pricas. A beginner may be tempted to buy scrap matals for his first castings, but this practice is not to be encouraged. Coppar alloys ara difficult to identify from appearance alone, so many alloys will and up in tha sama bin at tha scrap dealers. You could end up witb a mixture of yellow brass, aluminum bronze, and manganase bronze. Needless to say, you would find uncertain results in tha quality of tha finisbed product. Select your

QUICK»TIP

Those interested in precious metal or art casting may start with aluminum and red brass, but eventually move on to costlier substances. Essentially, that means a change in casting alloys to silver and gold.

Yellow gold comes in 10 carat (Kt) form with a melting point of 1450 F., and a flow point of 1635 F. As the alloy gets closer to pure gold, the melting and flow points rise; 18 carat gold melts at 1620 F. and flows at 1715 F.

White gold melts at 1625 F. due to the nickel content. 18 carat gold melts at a lower temperature because it is formed by an isotherm with 75% pure gold content.

Sterling silver melts at 1575 F., and flows at 1660 F.

Casting temperature is from 50 to 100 degrees above the flow temperature. With these precious metals, cast when the metal turns to a clear liquid with a mirror surface. Because the metals will "soak," or pick up impurities if kept heated too long, immediate casting is recommended.

There are different melt and flow points for these alloys because they are alloys, and each metal included has a slightly (or greatly) different melting point. For example, 13½ carat gold contains 56.25 percent gold, 8.8 percent silver, 30.7 percent copper, and 4.25 percent zinc.

Platinum cannot be gravity cast because of its high melting temperature—it is ether liquid or solid regardless of how high you raise its temperature. It freezes at once when you remove te heat used to melt it.

> **QUICK»TIP** You can, however, cast platinum in small castings (i.e., jewelry, or dental casting by using a special vertical casting machine called TROIT). Tubing sheet and so on is produced by hot forging. Cast iron is so-called because it has a wide solidification range, unlike platinum, whereby you can carry a ladle of cast iron around the block and then pour darning needle; it is still liquid like water.

material from a reputable dealer and reject any scrap with an uncertein color.

Casting elloys should reelly be purchased in ingot form. More uniform results and fewer rejects will make up for the higher rew materials costs. Bress and bronze are usually sold in 25-pound ingots, but they can be cut up into more convenient 4- or 5-pound chunks with a power hecksaw.

CHAPTER

9

Cores and Their Application

A core is a preformed haked sand or green sand aggregate inserted in a mold to shape the interior part of a casting which cannot he shaped hy the pattern.

A core hox is a wood or metal structure, the cavity of which has the shape of the desired core to he made therein.

A core hox, like a pattern, is made hy the pattern maker. Cores run from extremely simple to extremely complicated. A core might he a simple round cylinder form needed to core a hole through a huh of a wheel or hushing or it could be a very complicated core used to core out the water cooling channels in a cast iron engine hlock along with the inside of the cylinders.

Dry sand cores are, for the most part, made of sharp, clay-free, dry silica sand mixed with a hinder and haked until cured. The hinder cements the sand together. When the mold is poured the core

QUICK»»TIP

No matter how small a casting will be, too shallow a core box prevents good casting, because the shallow box tends to collapse around the core. If you have trouble with cores collapsing, before going to a lot of other trouble, try a deeper core box.

holds together long enough for the metal to solidify; the binder is cooked from the heet of the casting until its bonding power is lost or burned out. If the core mix is correct for the job, it can be readily removed from the casting's interior by simply pouring it out as burnt core sand.

This characteristic of a core mix is called its *collapsibility*. The size and pouring temperature of a casting determines how well and how long the core will stay together. A core for a light eluminum casting must collapse much more readily then a core used in steel beceuse of the different time, weight, and heats involved. Core sand, like molding sand, must have the proper permeability for the job intended. The gases genereted within the core during pouring must be vented to the outside of the mold to prevent gas porosity and a defect known as a *core blow*. Also, e core must have sufficient hot strength to be handled end used properly. The hot strength refers to its strength while being heated by the casting operation. Beceuse of the sbepe and size of some cores they must be further strengthened with rods and wires.

A core for a cast bronze water faucet must have a wire in the section which passes through the seat of the valve. Beceuse of the small diameter at this point, core sand alone would not have sufficient dry strength to even get the core set in the mold much less pour the cestings (Figure 9.1).

A long span core for a length of cast iron pipe would require rodding to prevent the core from sagging or bending upward when the mold is poured beceuse of the liquid metel exerting a strong pressure during pouring (Figure 9.2).

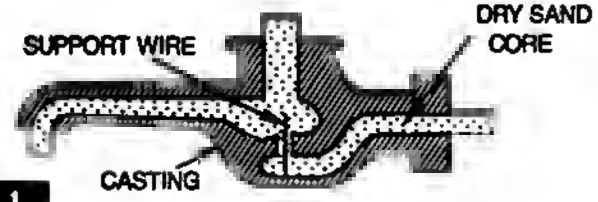

FIGURE 9.1

Dry sand core with support wire.

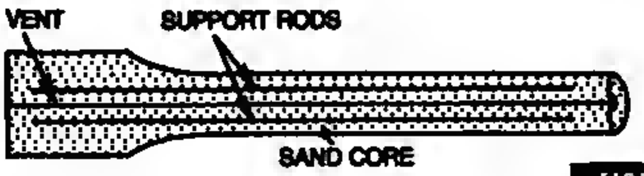

FIGURE 9.2

Rodded core.

Binders

> **QUICK TIP**
>
> **Core sand binders come in two basic types: those that set at room temperature; those that must be heated to set. Rubber cement and Portland cement need no heat. Oil binders, including linseed, vegetable, and other oils need to be set by baking. Furan uses a chemical catalyst as a hardener.**

There are many types of binders to mix with core sand. A binder should be selected on the basis of the characteristics that are most suitable for your particular use.

Some binders require no baking and become firm at room temperature. Examples are rubber cement, Portland cement, and sodium silicate or water glass. In large foundry operations and in some school foundries, sodium silicate is a popular binder because it can be hardened almost instantly by blowing carbon dioxide gas through the mixture.

Oil binders require heating or baking before they develop sufficient strength to withstand the molten metal. Linseed oil is considered one of the strongest binding oils. Vegetable, mineral, and fish oils are also used.

Sulfite binders also require heating. The most popular of the sulfite binders is a product of the wood pulp industry. It is sold in liquid form under the trade name of Glutrin and in the dry form under the trade name of Goulac.

Furan is the trade name of a chemical binder which is hardened by the use of a catalyst. There are many liquid binders made from starches, cereals, and sugars. They are available under a countless number of trade names.

A good binder will have the following properties:

- Strength
- Collapses rapidly when metal starts to shrink

QUICK»TIP Binders increase the properties of strength; collapsibility; non-distortioning; storability; and low water absorption. They disperse properly through the sand mix and produce an easily formed mixture.

- Will not distort core during baking
- Mainteins strength during storege time
- Absorbs a minimum of moisture when in the mold or in storage
- Withstands normel handling
- Disperses properly and evenly throughout the sand mix
- Produces a mixture thet can be eesily formed

Core Mixes

Teble 9.1 is e list of core mixes that I beve used for e number of years with good success.

If you are confused ebout core mixes, don't let it worry you. Foundry A produces the same type and weight of cestings es Foundry B. Foundry A bes 100 or more different core mixes. They use almost e different core mix for each job. Foundry B, doing the same kind of work, uses three different mixes, one for ligbt work, one for medium work, and one for beavy work.

Both produce good work. However, I am sure Foundry B's cost and problems are much less than A. This condition exists throughout the industry. For generel ell round core work in the smell or hobby sbop, e simple linseed oil bonded mix will suffice for 90 percent of the work.

Tbe simplest mix is by volume, 40 parts fine sharp washed and dried silice sand and 1 part of linseed oil.

It is common practice to add e small percentege of weter and kerosene. This makes it mix better and strip easier from the core box.

If the moisture is too low in the mix, the core will bake out too soft and if the moisture is too high, the core will bake out too hard and stick in the box when making the core. Most mixes work best wben just enough weter is added to make the mix feel damp but not wet. To blend your core mix start out with dry sand, nearly pure silica sand free from cley. Mix the dry ingredients, add the oil and weter, and finisb mixing.

Core sand mixes can be combined in a muller or paddle type mixer in small amounts on the bench by hand.

The core is made by ramming the sand into the core box and placing the core on a core plate to bake (Figure 9.3).

The box cavity is dusted with parting powder, usually made of powdered walnut shells, purchased as a core box dry parting. The box is rammed full of sand using the handle of a rawhide mallat to ram. Tha axcess is struck off level with tha side of a core maker's trowel. The core is then vented with a vent wire, a core plate placed on top, and the plate and box rolled over on tha bench. Tbe box is rapped on one side and then on the front and back to loosan the core.

The box is then lifted (drawn) off leaving the core on the plate. The plate is placed in tha oven to be baked or driad. When finisbed, it is removed from the oven and allowed to cool. It is then ready to use (Figure 9.4).

Stand-Up Cores

Stand-up cores (cores that can be stood on end to dry) are made in a split core box. The box is pinned together with pattern bushings. The box is held together with a C-clamp and it is rammed up using a dowel of suitable diameter. When rammed, it is then vented with a vent wire. The clamp is removed and the box placed on a core plate. The balf of the box away from the core maker is removed and the core is slid to tbe far side of the plate. The

TABLE 9.1

For brass and aluminum	
Fine river sand	10 parts
Wheat flour	¼ parts
Air float sea coal	3 parts
Rosin	1 part
For small castings	
New molding sand	15 parts
Sharp sand	5 parts
Linseed oil	1 part
For aluminum, heavy castings	
Sharp sand	30 parts
New molding sand	10 parts
Wheat flour	2 parts
Temper with molasses water	
For aluminum, medium castings	
Sharp sand	10 parts
New molding sand	5 parts
Wheat flour	1 part
Temper with molasses water	
Good mix for long skinny cores	
Sharp sand	8 quarts
Wheat flour	1 quart
Core oil	¼ pint
Quick collapse cores for aluminum	
Sharp sand	45 parts
Molding sand	45 parts
Powdered rosin	2 parts
Wheat flour	1 part
Mix for small cores	
Sharp sand	25 quarts
Molding sand	15 quarts
Linseed oil	1 quart
Brass pump core mix	
Silica	32 parts
Fire clay	1 part
Silica flour	4 parts
Add rosin to desired dry strength	
Small diameter bushing cores	
Sharp sand	80 parts
Corn flour	2 parts
Oil	1 part

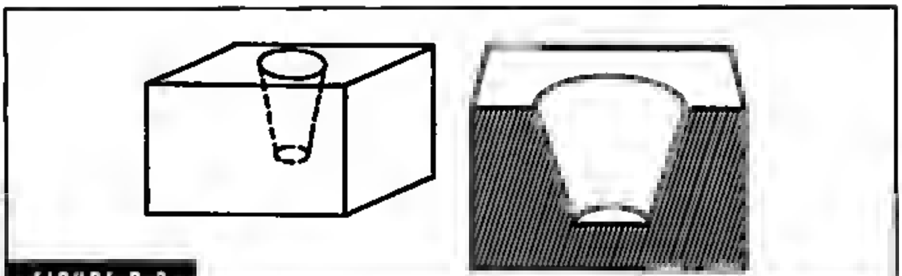

FIGURE 9.3

Simple dump core boxes.

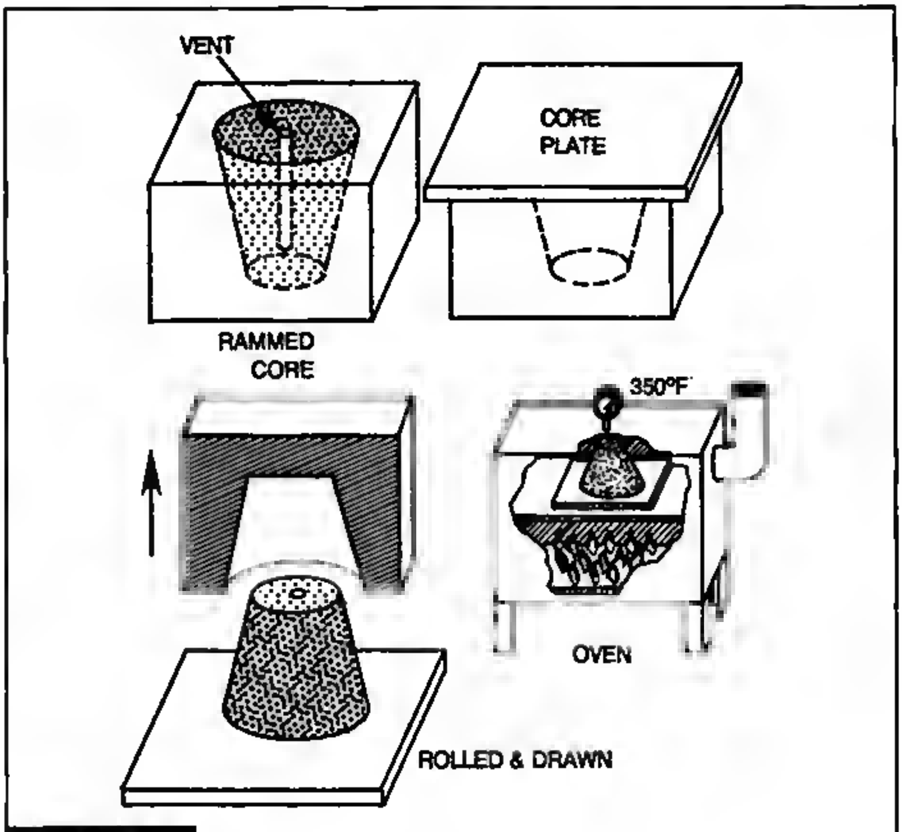

FIGURE 9.4

Use of dump core box.

remaining half of the box is removed, leaving the core standing free. This is continued until the core plate is full, or until you have sufficient cores. The plate is then ready for the core oven (Figure 9.5).

Stand-up cores are often made in gang core boxes (Figure 9.6). Stock or round cores, when too tall to stand on end, are made in a split box and rolled on to a core plate for drying (Figure 9.7).

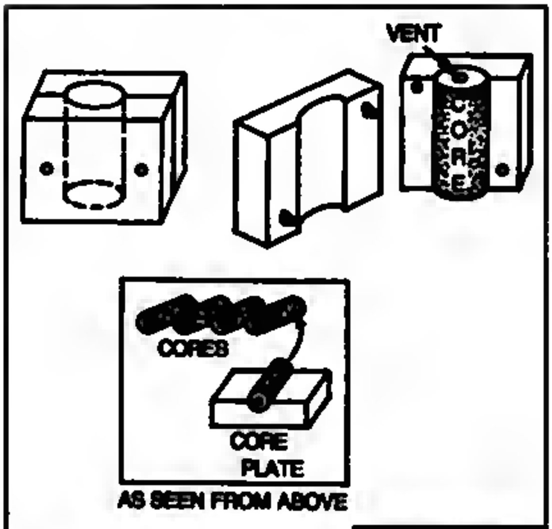

FIGURE 9.5

Stand-up core box.

Pasted Cores

Cores can be made in halves and after they are dried, glued together to make the complete core. If the core is symmetrical, a half box is all that is needed (Figure 9.8).

After the two halves of the core are dried, a vent is scratched along the center line of one half and the sections are glued together with core paste. The seam is then mudded with a material known as *core daubing*. Both core paste and daubing can be purchased or made. For homemade core paste use enough wheat flour dissolved in cold water to produce a creamy consistency.

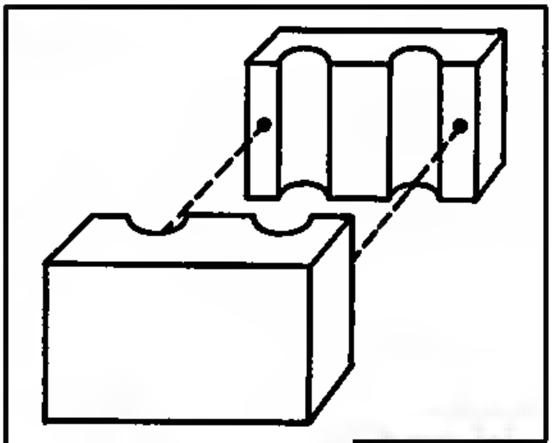

FIGURE 9.6

Gang core box.

For a good core daubing mix, fine graphite is mixed with molasses water (one part molasses to 10 parts water). Enough graphite is added to the molasses water to make a stiff mud.

Another good daubing mix is graphite and linseed oil mixed to a stiff mud.

After a core has been pasted and daubed, it is a good idea to return the core to the core oven for a short period to dry the paste and daubing.

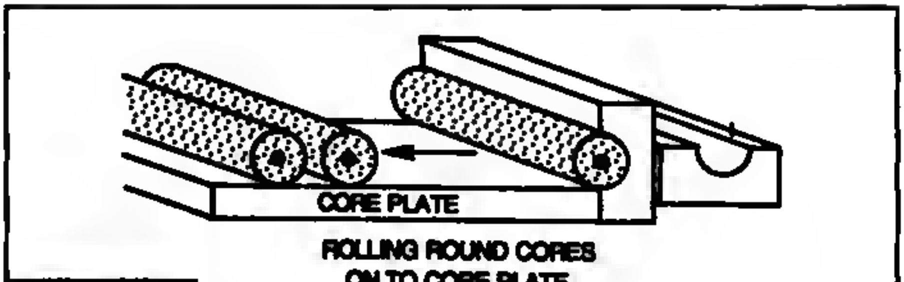

FIGURE 9.7

Use of core plate.

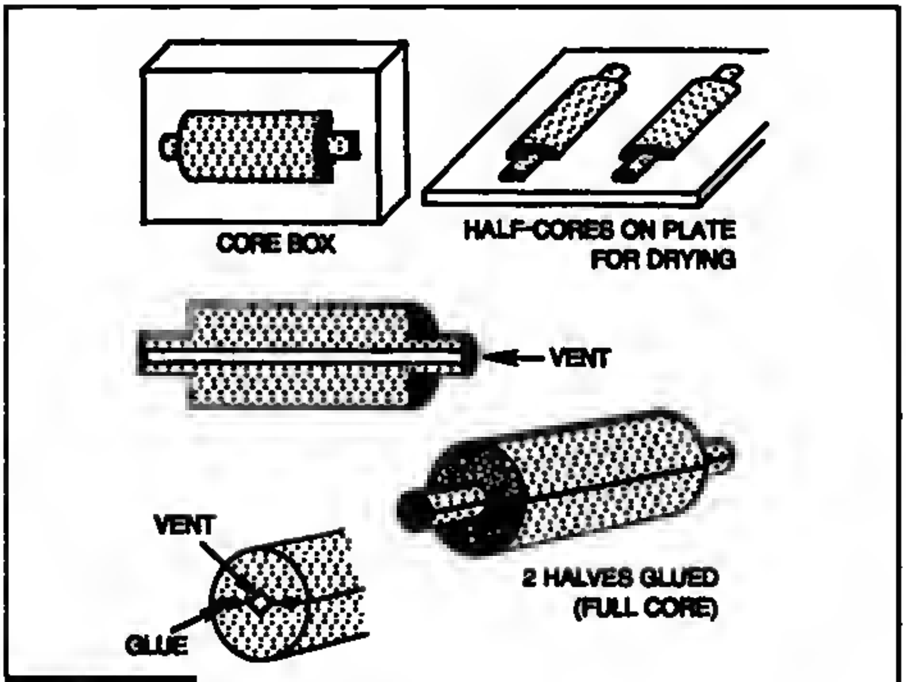

FIGURE 9.8

Pasted cores.

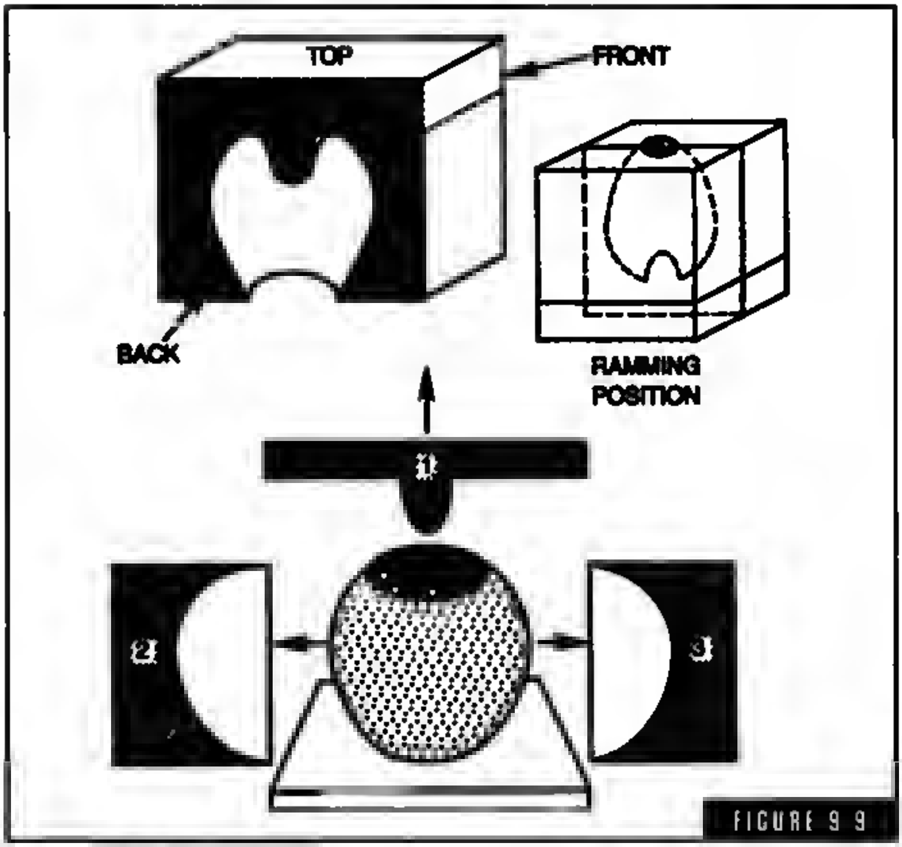

FIGURE 9.9

Three part core box.

Three Part Core Box

This box consists of a top, front, and back section. The box is assembled and placed top down and clamped. You ram it up, put on a core plate, roll it over, and rap it. Remove the top (which forms the negative section on top of the core), then remove the main box from the core as you would any simple split box (Figure 9.9).

Loose Piece Box

A loose piece box is a box which contains a loose piece (or drawback) to form a particular shape to the core. The loose piece is placed in position in the box, the core rammed, rolled over on a plate, rapped, and

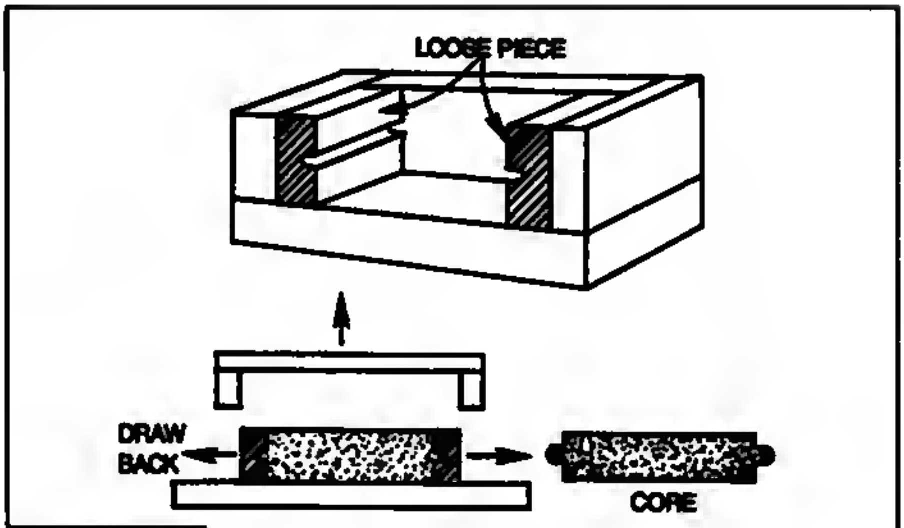

FIGURE 9.10

Loose piece core box.

lifted off. The loose piece remains with the core on the plate and is drawn back to remove it (Figure 9.10).

The core box may have one loose piece or many. Sometimes a loose piece may have a loose piece of its own.

Swept Core

A core can be produced by a suitably shaped sweep (or stickel) and guide rails. The guide rails are clamped to a core plate. Core sand is heaped in between the rails and swept to shape by the sweep form. When finished the guide frame is removed and the core dried. The swept core might have several different diameters and may be curved. The shape dictates the frame construction and the number and shape of the strikes. Flat cover or slab cores are more often than not swept up on a core plate with a simple frame and flat strike off bar (Figure 9.11).

Core Driers

A core drier is a support used to keep cores in shape during the baking or drying. Most core driers are made of cast aluminum. The core drier

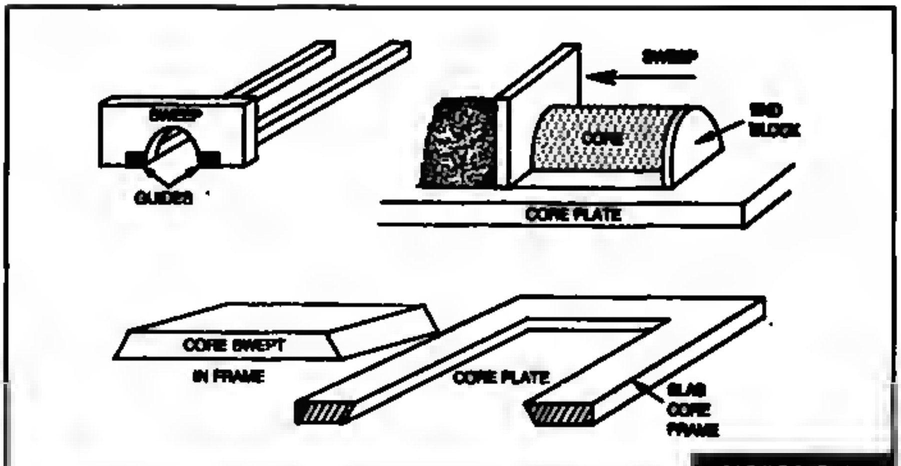

FIGURE 9.11

Swept core.

is similar to a half core box but fits the core more loosely than the box and only sufficiently to prevent the core from collapsing or sagging before and during drying. The core is rammed in the usual manner. The side of the core box that presents the face of the core that will rest in the drier is removed. The drier replaces this half box. The box and drier are rolled over and the box removed, leaving the core resting in the drier ready to be dried (Figure 9.12).

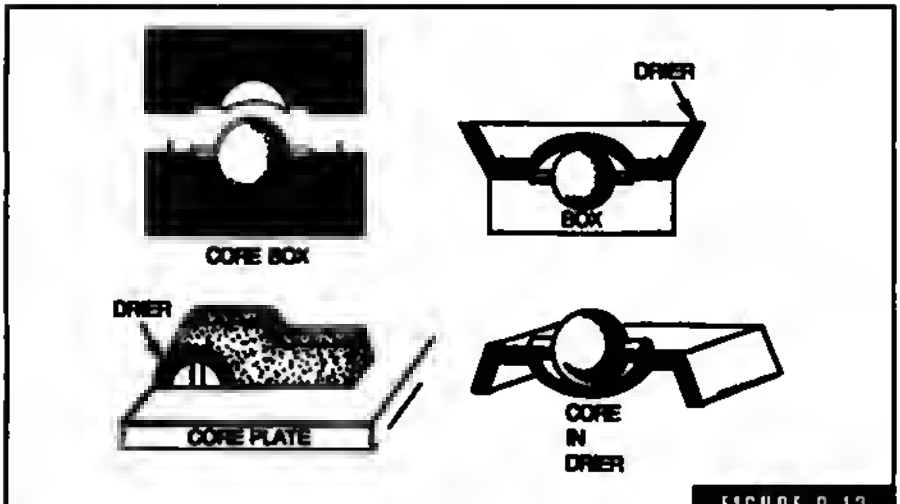

FIGURE 9.12

Core driers.

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flask, hut increases core cost, a hetter solution is to use one core to produce two castings. A *dumbbell* core produces two castings having a common print (Figure 9.15).

QUICK TIP

Chaplets are spacers to maintain cores. Three types are common: stem, motor, and radiator. Stem and motor chaplets are placed after mold is made; radiator chaplets are rammed up in the mold during mold-making.

Chaplets

Cheplets consist of metallic supports or spacers used in a mold to maintain cores, which are not self-supporting, in their correct position during the casting process. They are not required when a pattern has a core print or prints which will serve the same purpose. Cheplets are purchased in a wide variety of sizes and shapes to fit just ahout any need or condition. The three most common types are the stem chaplet, motor cheplet, and radiator chaplet.

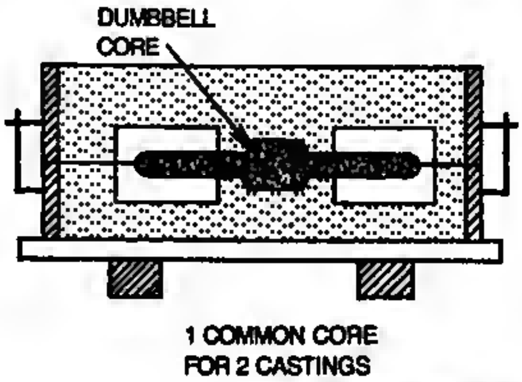

FIGURE 9.15

Dumbbell core.

Motor chaplets and stem chaplets are placed or set in the mold after the mold is made. Radietor cheplets are rammed up in the mold during the molding operation.

On many gas stove hurners, hot water heater hurners, and many types of gas furnace hurners, you will note that there are a series of projections or little humps on the casting face hoth on the cope and drag. They are more noticeahle on the hottom face. These humps or knots are made hy radiator chaplets used to hold the core centrally located when these hurners are cest. The pattern is drilled wherever a chaplet is needed. These drilled holes are slightly larger in diameter than the stem diameter. The chaplet hes a knot hehind the husiness end of its stem that allows the chaplet to only stick into the hole in the pettern as far as this knot. The distance from the knot to the end of the stem represents the metal thickness of the casting. The end of the chaplet thet is held in the molding sand has a plate-shaped head to give it a good purchase in the rammed molding sand. This prevents it from moving or heing pushed hack by the force of the core as it tries to float when the mold is heing pourad.

TROUBLE-SHOOTING

SYMPTOMS

If a hollow casting leaks, check the chaplets. If radiator chaplets are used, the casting must be poured hot enough to fuse the chaplet. A rusty or dirty chaplet will cause the same problem.

The molder sets the stem chaplets into the holes in the drag half of the pettern. He rams the drag, rolls the flask over, and sets the cope chaplets. He then rams and finishes the cope. When the pettern is removed, the stems of the chaplets stick through the molding sand the exact distance required. The core is set on the drag chaplets and the chaplets in the cope come down and clamp the core between the cope and drag chaplets when the mold is closed.

When tha casting is poured, the projecting chaplets hold the core in place until the metal starts to solidify, then these projections fuse or weld themselves into the metal that surrounds them.

A leaking hollow casting sometimes results when using rediator chaplets. This prohlem arises when the casting is not poured hot enough to properly fuse the chaplet, or e rusty or dirty chaplet is used by the molder. After the casting is shaken out, the stem and hesd that was in the sand is broken off. The chaplet is provided with e hreak off notch (Figure 9.16).

Chaplets are seldom, if ever, used in nonferrous casting because the pouring temperature is not high enough to melt and fuse the chaplet.

A core which is set in plece during the ramming of e mold to cover and complete e cavity partly formed by the withdrawal of e loose piece on the pettern is called e *cover core.*

Ram-Up Core

A ram-up core is e core that is set against the pettern or in e locator (slot, etc.) in the pettern. The mold is rammed and when the pettern is drawn, the core remains in the mold (Figure 9.17).

As you can see, there is an endless variety of types, kinds, and uses of cores. New uses and kinds are continuously coming up as new problems present themselves.

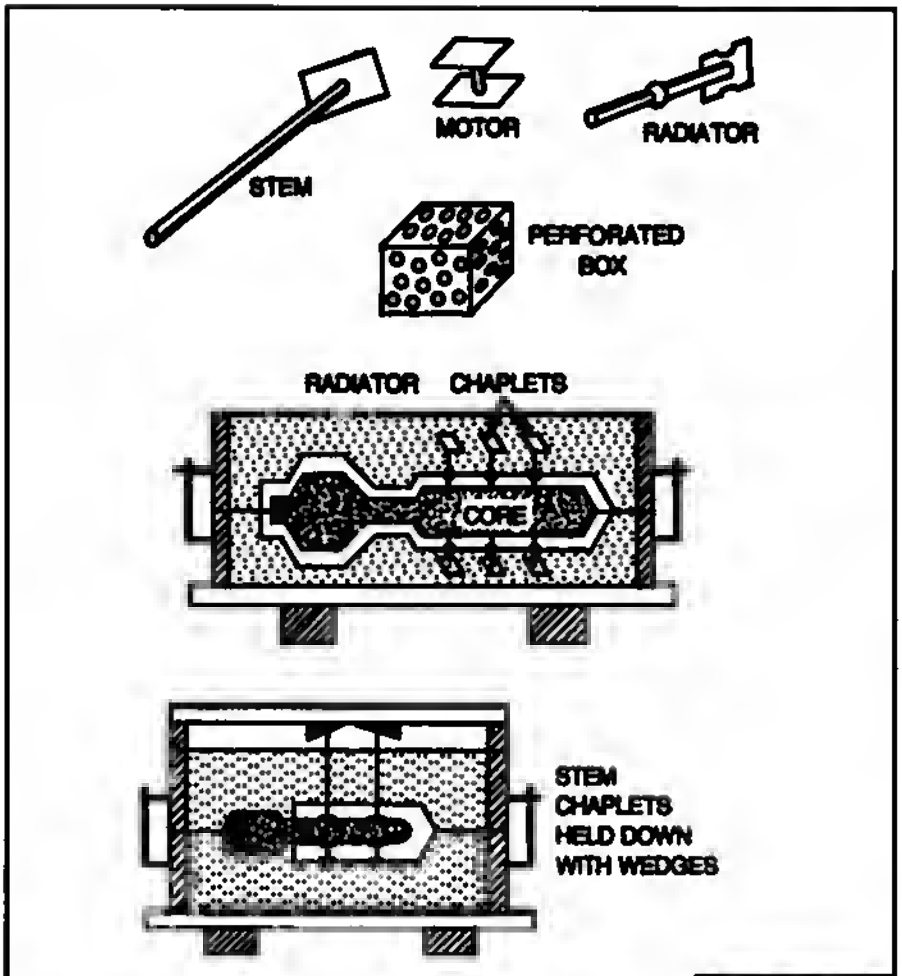

FIGURE 9 16

Chaplets.

Core Washes

Cores are sometimes coated with a refractory wash to increase the core's refractiveness and to produce e smoother metal surface in the cored cavity of the casting. These materials are called *washes*. They can be purchased in a variety of types and refractive strengths. A common homemade wash is graphite and molasses water mixed to e nice paint consistency.

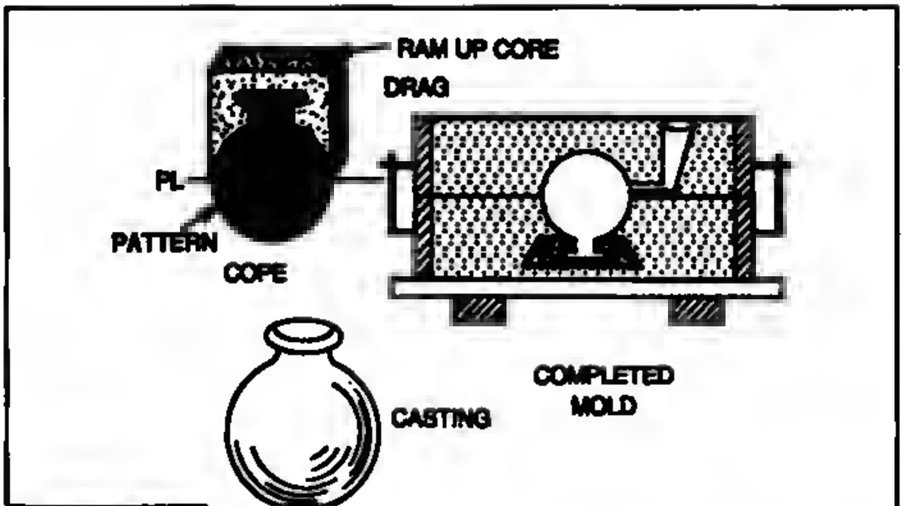

FIGURE 9 17

Ram-up core.

Core Plates

Core pletes, es you have no doubt guessed by now, are flat plates on which cores are baked in e core oven. They can be made of cast aluminum which hes been normalized and machined to e true flat surface. Composition plates of Transite, a composition asbestos mill board manufactured by Johns Manville Co., can be purchased in a range of sizes and thicknesses from any foundry supply house.

Vent Wax

Vent waxes are tapers of various diameters made of a wax and rosin combination. The vent wax is rammed up in the proper position in a core and, when the core is baked, the wax melts, leeving a vent channel. This wax is sold in spools by supply houses.

Core Ovens

Cores are baked to set the binder. The usual temperature range for oil bonded cores is from 300 to 450 F. The time required varies with the bulk of the core. A large core might take several days to bake; a small

core might bake out in an hour or less. When an oil core is completely baked the outside is a rich dark brown, not black or burned. Tbe core must be cured completely through with no soft centers. Only experience and triel and error will teecb you bow to bake cores.

It is common prectice to hollow out large cores to decreese the baking time and ensure an even bake througbout.

Another fector wbich relates to the time and tempereture required to properly dry e core is the type and amount of binder used. Oil binders require botter and quicker baking than rosin, flour, and goulec hinders.

The core oven, wbich is usually e ges fired oven with tempereture controls, is equipped with sbelves on wbich to set the core pletes and cores for baking. Some have drawers like e file cehinet which pull out to loed and unloed. When the drawer is pulled completely out, its beck closes off the opening in the oven and prevents beet loss. This type of oven is also mede with semicircular shelves wbicb swing out.

The core oven can consist of e square or rectangular hrick oven with doors. The bottom of the oven is floor level. The cores are pleced on recks wbich, wben full, are rolled into the oven. Tbe oven is closed and the cores are baked. It is common prectice to loed the ovens one dey with the cores required for the next day and to dry them over night. The leed time required for cores to the molder will vary from hobby sbop to shop.

You can hake cores in your kitcben oven or there are many different kinds of mechanized mecbinery wbicb can be purcbased to make cores, completely eutometed to semi-eutometed, hlowers, extruders, shell mecbines, etc.

Shell Coremaking

Shell cores, are coming like shell molding, are hecoming more and more popular for certein types of work. Sbell cores came to the front very repidly. One of the most important things to consider in designing with e sbell core is to use it when it offers e definite edvantege over an existing dry or green sand core.

Carefully consider the casting, its design, etc., to determine wbether e decided edvantege can be realized by use of e shell core. Look for an overall reduction in cost, less machining, eliminetion of

an operation, etc. Don't use a shell core to core out something like the hole in a frying pan handle or some such foolishness as that.

Sometimes a combination of shell and dry sand cores in the same job is the best practice. Use the methods and types of materials you have to the best advantage. Avoid foolish or ridiculous applications. I have seen some errors, but I also have seen some very ingenious applications of shell cores that resulted in concrete advantages and dollar savings.

So far as I know, there is no difference in the sand, binder, or method employed to make a shell core for use in nodular or any other type of metal, whether ferrous or nonferrous. I have seen shell cores used to make a gray iron casting, then used to produce the same job in brass with no change in equipment or cores. It is my understanding, however, that the most difficult metals to cast in conjunction with shell cores are certain classes of steel and the copper-base alloys with more than 6 percent lead.

A shell core sometimes has a tendency to be thin at the vertical surfaces that are at right angles to the body; that is, the sides of the core that forms the sides of your rings. However, with a ½-inch wall in the casting, the ring projections on the core undoubtedly will fill up completely with sand and be solid (Figure 9.18). Using a thin, hollow shell core over a long unsupported span completely surrounded by metal is

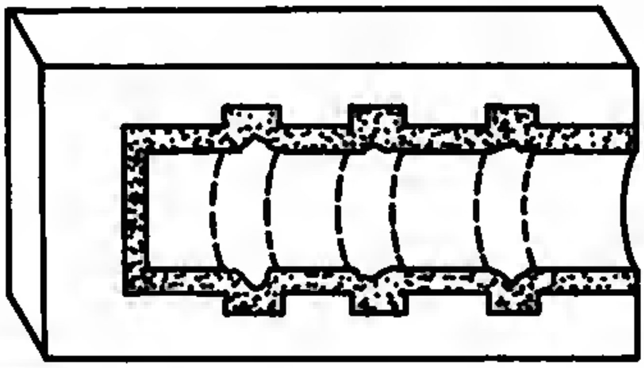

FIGURE 9.18

Ring projections on the core fill up with sand and become solid.

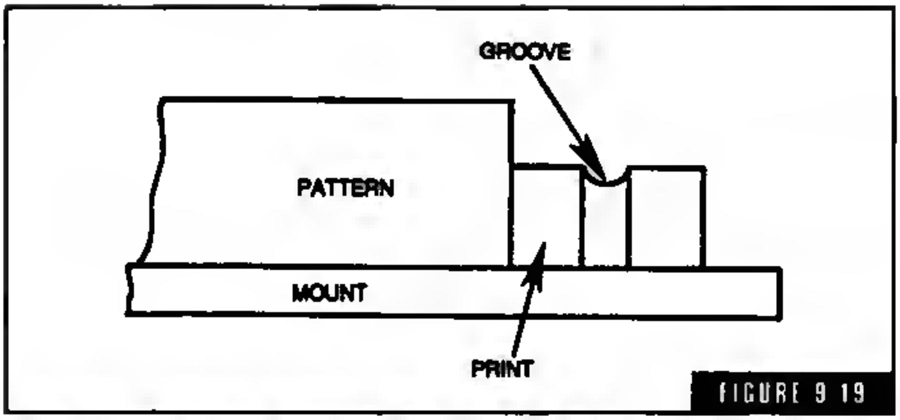

FIGURE 9.19

Cut a groove around the core prints when using shell cores.

like trying to duck a balloon under water. If you have no core rods or other stiffening or supporting members, the lifting force on the core is somewhat greater because of its lightness and its hollowness. I have seen shell cores reinforced internally with molding sand or just plain dry, sharp sand.

The print on the open dump end of some cores should be long enough to ensure a good seal to prevent metal from bleeding or running into the core. Most hobby shops using shell cores cut a groove around the core prints, a little way back from the casting (Figure 9.19). This procedure will give you a little green sand crush to form a tight seal around the core print. Dough roll, core paste, or one of the prepared seals with a little corn flour sprinkled on makes a good seal.

The percentage of resin needed in the mix seems to vary from sand to sand, increasing with sand fineness. The usual amount is about 5 percent by weight, but there is a critical amount which must be worked out. As the amount of resin is increased, the resulting shell or core becomes smoother and harder. It is with this condition that you might run into penetration, cracks, etc. A high percentage of resin makes a hard and brittle core. It seems that above 8 percent resin, cores are too hard and brittle. Below 4 percent, they usually are too weak. I believe that the proper ratio of sand to binder will produce the desired results.

The sand and resin may be mixed dry in a suitable muller or a Y-type blender and used in that condition, or the sand may be resin coated.

Sand mey he coeted with resin hy either the hot or the cold process. Beceuse the latter can he carried out easily in the smell shop, I will touch on it hriefly.

Sand and the proper amount of resin—ahout 2.5 pounds per 100 with round grain and 4 pounds with suhangular sand—are mixed dry in e muller for 1 to 2 minutes. Then an elcohol–water solvent is added slowly. The solvent is 3 parts denatured ethyl or isopropyl elcohol to 1 part water hy weight. The amount varies with resin. Use 0.72-pound solvent for 2.5-pound resin mix, and 1 pound solvent for 4-pound resin mix.

Mulling is continued for 10 to 20 minutes until the solvent has evaporeted and the sand is dry. Thet condition is indicated hy eppearance and can he checked hy picking up a handful of the sand. It should show no strength. Mulling is stopped es soon es the sand mix is dry. If you try this, don't forget thet the muller should he hooded and hitched to an exhaust system.

This mixture is designed to coat every grain with a coating or shell of resin, preventing the possihility of segregetion, which sometimes occurs in sand resin mixes. Any resin which is cepehle of heet polymerization can he used, such as urea formaldehyde or phenol formaldehyde. Use e top-quality, clay-free, weshed and graded suhangular silice. It should he helow 2 percent clay AFS.

False Coring of Bas-Reliefs

The field of art casting is for the most part a specialty and is full of tricks requiring lots of experience.

The system most commonly used for making e cesting with undercuts, such as has-reliefs, is celled *false coring* (Figure 9.20). Eech recess or undercut is filled with sand in such a manner thet it leaves a print on the main face of the mold where it can he attached. These portions heve to he made so that the main face of the mold can he lifted from the fece of the pettern without hreaking or tearing up. At the same time, eech felse core must he mede so thet it can he removed from the pettern without damege to it and then he placed in its proper print on the mold face.

French sand is used extensively for this type of work heceuse it can he rammed hard and dried hard without the fear of hlowing, etc.

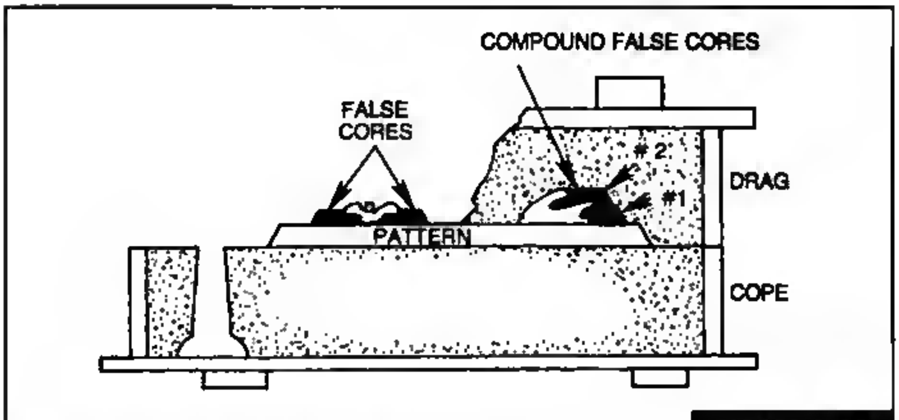

FIGURE 9.20

Bas relief with a backdraft requires the use of false cores.

TOOLS

French and Yankee sands are for fine mold-making. Both can be rammed hard and then dried hard without problems.

French sand comes from e little town near Paris. *Yankee sand* is wbat often is celled synthetic French. It is used widely for fine work. In fect, l have seen Yankee sand do just as well es Frencb sand. With either sand, if tha whole mold is put up, it should be rammed carefully and bard, wasbed with plumbago and oven-dried. If Yankee or French is used es e facing, skin drying elone will suffice.

French sand bes e grain fineness of 140 to 175 with the cley removed, carries ebout 16 percent cley substance, hes e permeebility of 18 et 7 percent moisture, and avereges a green compression strength of about 10. With Yankee sand, grain fineness is ebout 184, clay content about 19.5 percent, and permeability approximetely 17. Green compression strength runs to an everage of 16.

Should the bas-reliefs be flatbacked, as most of them are, the cope is made up flet on a smooth, level board. It is struck off and rolled over on a bed. Tha pettern is then placed on the cope in the correct position for ramming the dreg with the roccoco face up. Tbe next move is to study the arrangement carefully and decide about the type of felse cores necessary.

Each is made by carefully ramming into the undercuts, bearing in mind that they leter must be removed and reassembled on the drag face of the mold in their correct position. Use wires and metal lifters

wbere necessary. Often because one undercut is above another, one false core requires one or more false cores itself.

Make sure thet each false core hes e sufficient print to locate it correctly with respect to the finisbed drag. Eech false core must heve correct draft to allow the drag to be rammed up and removed in good sbape. It should be remembered thet if your piece bas roccoco and backdrafts on eacb side, the procedure is the same with the exception that you bave to use an odd-size double roll, treeting eacb side singly.

After all the false cores bave been made, they are marked in such a manner that they will leave an identifying mark on the drag for relocetion. The face is dusted with parting and the drag flask is placed, carefully rammed up, and struck off. A bottom board is rubbed in place. Drag and bottom boards are lifted off and rolled over on rails. Tbe false cores then are finished from the undercuts and glued or nailed into their correct positions on the drag face. Tbe rest is as usual—skin dry, oven dry, or use wbatever other system you prefer.

Some operators make up their false cores and bake them with infrared lamps just wbere they are, on the face of the pattern, before they ram the drag. Tbis procedure can he used with French, Yankee, or oil-sand cores provided thet the pattern is mede of a meterial which will take the beat. A wooden soldier bere and there, cut to give both a print and e bandle by which to bandle the false core, sometimes can be used to an advantage.

I beve seen some old Frencb petterns carved in mahogany which were loaded with roccoco and gingerbread. They are also loaded with undercuts and heckdrafts, which were only optical illusions. To create the illusion of folds and undercuts without actuelly baving any is my idea of being really clever.

I also bave seen the old cup, seucer, and spoon made with false cores in a two-part flesk. Try thet some time.

CHAPTER

10

Patterns and Related Equipment

A pettern is e sheped form of wood or metal around which sand is packed in the mold. When the pattern is removed the resulting cevity is the exect shape of the object to he cast.

The pattern must he designed to he easily removed without damege to the mold. It must he accurately dimensioned and durahla enough for tha use intended.

Each different item we wish to cast prasents unique prohlems and requirements. Especially in large foundries, there is a close relationship hetween the pattern maker and the molder. Eech is eware of the capabilities and limitations of his own field.

Throughout the industry, pattern making is a field and an art of its own. Tha pettern maker is not e molder nor the molder e pettern maker. This is not to imply that the pattern maker cannot make a simple mold or the molder make a simple pattern hut each may soon reach a point in the other's field heyond his own skill and experience.

In the hohhy or one-man shop, however, pettern and mold making are so closely interrelated that they become almost one continuous operation. This chapter will acquaint you with some of the various types of patterns and their requirements.

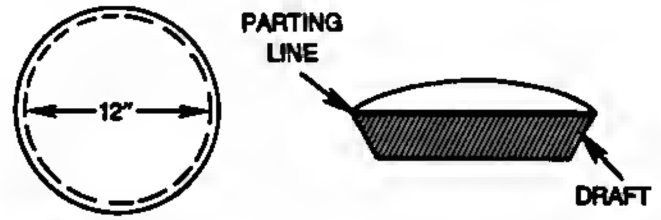

FIGURE 10.1

Disc pattern.

Draft

To illustrate some of the important pattern characteristics, we will use as an example a simple disc pattern. The object we want to cast is 12 inches in diameter and 1 inch thick. The edge of the disc is tapered from the top face to the bottom face (Figure 10.1). This taper is known as the *pattern draft*. This draft is necessary in order that the pattern can be removed easily from the mold causing no damage to the sand. Pattern draft is defined as the taper on vertical elements in a pattern which allows easy withdrawal of the pattern from the mold. The amount of draft required will vary with the depth of the pattern. The general rule is ⅛-inch taper to the foot which comes out to about 1 degree. On shallow patterns such as a disc, 1/16-inch taper, 0.5 degree, is sufficient.

Shrinkage

Now back to the simple disc pattern. If we wish the casting to come out as cast to the dimensions of 12 inches in diameter and 1 inch thick, we must make the pattern larger and thicker than 12 × 1 inch to compensate for the amount that the metal will shrink when going from a liquid to a solid. This procedure is called *pattern shrinkage*. It varies with each type of metal and the shape of the casting.

The added dimensions are incorporated into the pattern by the pattern maker using what is called *shrink rulers*. These rulers are made of steel and the shrinkage is compensated for by having been worked proportionately over its length. Thus a 1/16 inch-shrink rule 12 inches

long will ba actually 12 3/16 inches long, hut will look like a standard rule. But, when laid out egainst a standard ruler it will projact 3/16 inch past the standard ruler. These rulers coma in a large variety of shrinks. Ganarally tha shrinkaga allowance for brass is 3/16 inch per foot, 1/8-inch per foot for cast iron, 1/4-inch per foot for aluminum, and 1/4 inch for staal. This would hold true for most small to medium work. For larger work, the shrinkage allowance is lass, in soma cases 50 percent less. Where a small casting in steel would require 1/4 inch per foot shrinkage allowanca, a vary larga stael casting might require only 1/8 inch per foot shrinkaga allowance. So, from this wa see that if wa wish to cast a bar in brass 1 foot long wa must make the pettern 1 foot, 3/16 inches long.

Machining Allowance

Now the plot thickens. Say tha disc we want in brass requires that tha outer diameter of the casting is to ba machinad (tha 12-inch dimansion is a machined dimension). We must then allow for mechining to our 12-inch dimansion. This allowanca must be in addition to tha shrinkaga and draft allowance taken at the short side of the pettern or smallest diameter (Figure 10.2).

Wa must hava a pattern dimansion of 12 5/16 inchas. Tha 5/16 inch allows for shrinkaga plus 1/16 inch for matal to come off. So wa need an actual diamater on the small and of our pattern of 12 3/8 inches.

If wa dimension our layout as 12 1/16 inches (tha 1/16 inch for machining) and we usa a 3/16-inch shrink rular to measure this dimansion, then

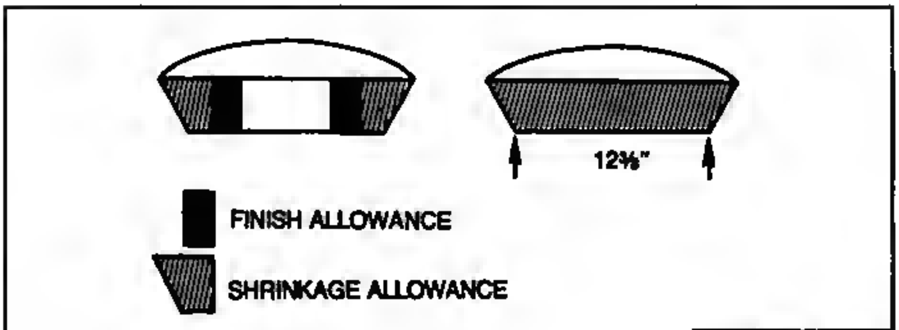

FIGURE 10.2

Finish and shrinkage allowance.

> **TOOLS** To determine shrinkage allowances, the use of shrink rulers is helpful. Shrink rulers come in different sizes, including 3/16-, 1/4-inch, and other sizes.

when you build the pattern it will come out fine. Or, make your pattern layout read 12 inches in diameter taking tha 12-inch dimension off of a 1/4-inch shrink ruler.

Approximate finish allowances, including the draft are, brass 1/16 incb; aluminum, 1/8 inch; cast iron, 1/8 inch; cast steel, 1/4 inch.

On a blueprint given to tha pattern maker for large projects, all finishes should ha noted (turned, ground, etc.). He will then know from exparience how much to allow and how much shrinkage to add to the pattern.

Production Pattern

In tha casa of tha disc, if you ara only going to maka a casting from tha pattern now and again, ona at a tima, dimension as just dascrihad. This pattarn is called a *production pottern*, ona from which tha actual castings are produced.

Master Pattern

Now suppose we want to make one or more production patterns out of cast aluminum from which wa intend to make production aluminum castings. In this case we need a wood pattern from which to cast our production pattern. If we wanted as our finished or end product a cast aluminum disc, we would have to make our wood pattern with a doubla aluminum shrink rula or 1/2 inch per foot shrinkage. Because wa are going to take 1/4-shrinkage in going from our wood pattern to our cast pattern and another 1/4 inch to our and product, thesa rules are called *double shrink rulers.* If we were going from a wood pattern to an aluminum production pattern to a brass casting as an end product the shrinkaga allowance on the wood pattern would hava to be 1/4 × 3/16 or 12/16 inch plus finish, etc., if any. This type of pattern (the wood) is called a *master pattern*—a pattern from which the production pattern or patterns ara made.

Parting Line

On the simple disc pattern of Figure 10.1, note that the upper face of the pattern is designated as the *parting line* or *porting foce*. By this wa

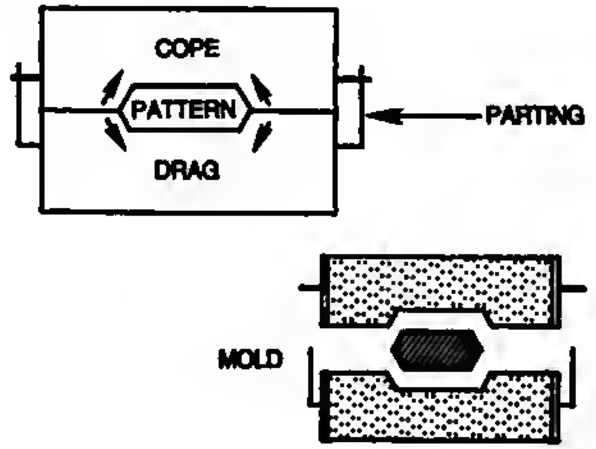

FIGURE 10.3

Parting line.

mean a line or the plane of a pattern corresponding to the point of separation between the cope and drag portions of a sand mold. Tbe parting may be irregular or a plane, because the mold must be opened, the pattern removed, and then closed for pouring without damege to the sand. The parting line must be loceted where this can be accomplisbed. The portion of the pattern in the cope must be drafted so the cope can be removed and the same for the drag (Figure 10.3).

QUICK TIP

Parting lines must be flat or *drafted* so that the mold can be opened. Drafting is the sloping of vertical areas to allow parting.

Any vertical portion of the pattern in either the cope or drag portion must be drafted or tapered as sbown in Figure 10.4. The junction or cbange of draft angle indicates the proper position of the parting line.

Back Draft

If the pattern were sbaped as in Figure 10.5 and the mold parted et its upper face, the back draft would prevent its removal without damage to the mold.

A back draft is a reverse taper whicb prevents removal of a pattern from the mold.

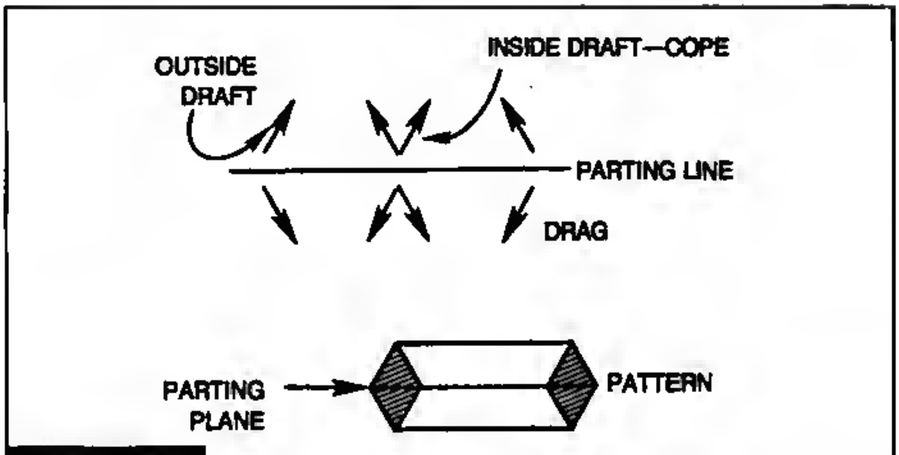

FIGURE 10.4

Locating parting line.

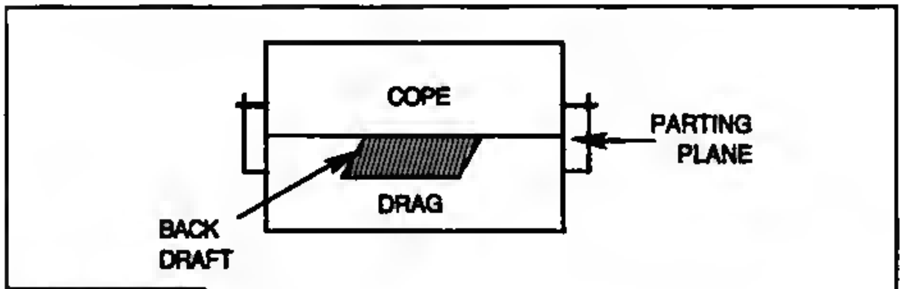

FIGURE 10.5

Back draft.

Gated Pattern

The gate is the channel or channels in a sand mold through which the molten metal enters the cavity left by the pattern. This channel can he made in two ways. One is hy cutting the channel or channels with a gate cutter, or by the pattern having a projection attached which will form this gate or gates during the process of ramming up the mold (Figure 10.6).

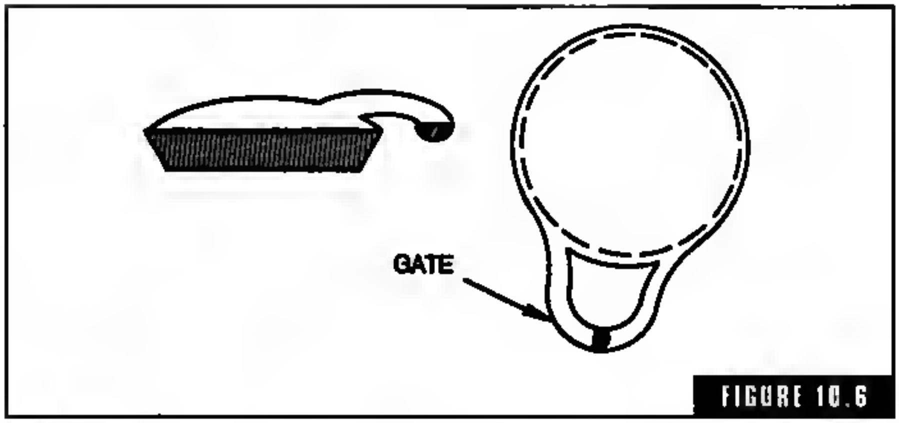

FIGURE 10.6

Gated pattern.

If e pattern is mede for a gete, hut not etteched to e pattern and only pleced egainst it while making the mold, this pettern is celled e *set gate pattern.*

Split Pattern

A split pettern is e pettern thet is mede in two halves split along the parting line. The two halves are held in register hy pins called *pattern dowels.* The pettern is split to fecilitate molding (Figure 10.7).

The dowels hold the two halves of the pettern together in close, eccurete register, but et the same time are free enough thet the two

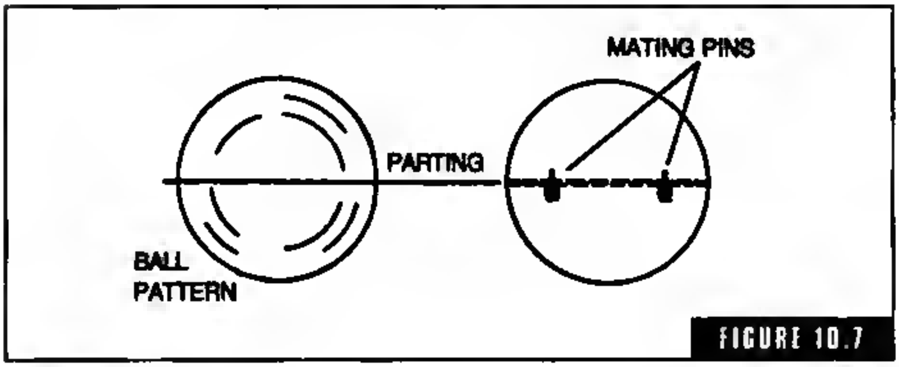

FIGURE 10.7

Split pattern.

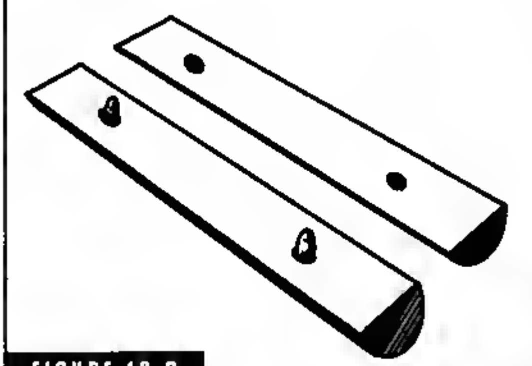

FIGURE 10.8

Offset pins.

halves can be separated eesily for molding like the pins and guides of the flask.

The dowels are usuelly installed off center in such a manner that the pettern can only be put together correctly (Figure 10.8).

Medium Pattern

A pettern that is used only occesionelly or for casting a one time piece is usually constructed as cbeaply es possible. If it is a split pattern, wood dowels are used for pins and fit into holes drilled into the matching helf. This type of pattern is called a *medium pattern.*

A core of preformed baked sand or green sand aggregete is inserted in e mold to shape the interior part of a casting which cannot be shaped by the pattern.

When e pettern requires e core, a projection must be mede on the pattern. Tbis projection forms an impression in the sand of the mold in which to locate the core and hold it during the casting. These projections are celled *core prints* end are part of the pettern (Figure 10.9).

Sometimes it is possible to meke e pattern in such e wey that e core will remain in the sand when the pattern is removed. The pattern for e simple shoring washer, illustrated in Figure 10.10 is mede in this way.

Mounted Pattern

When a pattern is mounted to a hoard to facilitate molding, it is called e mounted pettern. In this case, the mount bas guides on each end which metch up with the flask used to make the mold. The plate is placed between the cope and drag flask, the drag rammed and rolled over. The cope is then rammed and lifted off. The plate with the pattern etteched is lifted off of the drag helf. The mold is then finisbed and closed (Figure 10.11).

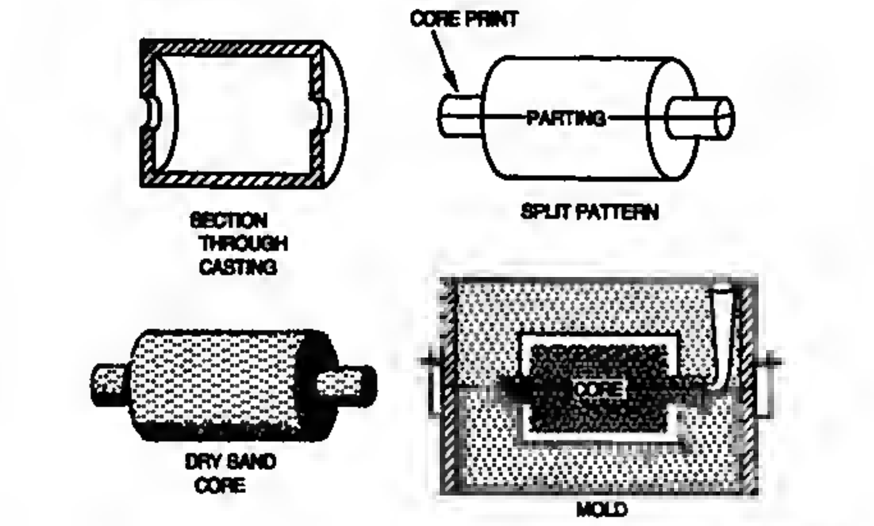

FIGURE 10.9

Core prints.

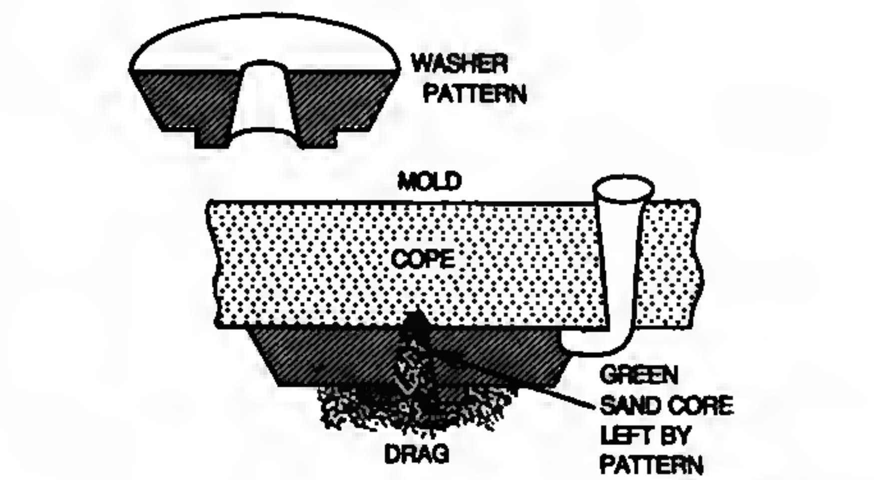

FIGURE 10.10

Self-coring pattern.

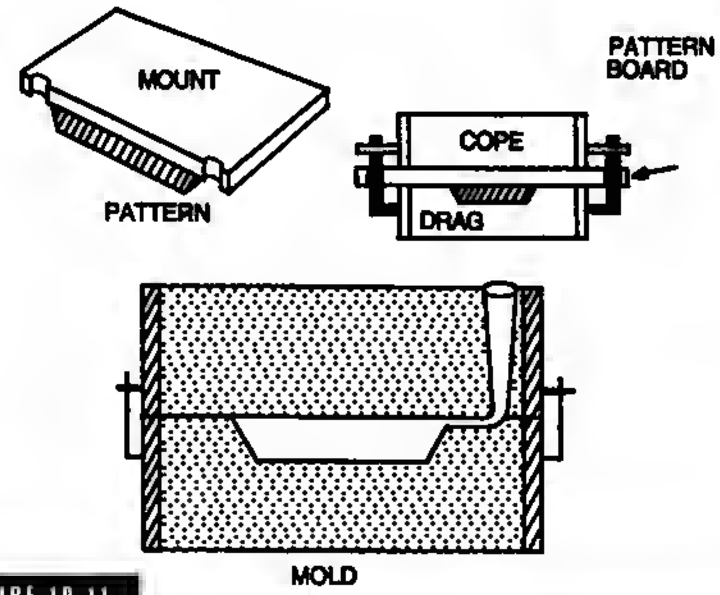

FIGURE 10.11

Mounted pattern.

Matchplate

The matchplate is the same as the mounted pattern with the exception that when you have part of the casting in the cope and part in the drag (split pattern), these parts are attached to the board or plate opposite each other and in the correct location. When the plate is removed and the mold is closed, the cavities in the cope and drag match up correctly. The molding procedure is the same as for one sided mounted plate (Figure 10.12).

In most cases all the necessary gating runners, etc., are built right on the plate. The matchplate might have only one pattern or a large quantity of small patterns.

TOOLS Cope and drag pattern mounts use female guides on the drag (lower part) and male guides on the cope (upper part). These must match the flask used.

Cope and Drag Mounts

In this case you have two separate pattern mounts. One is fitted with female guides for the drag and one is fitted with pins for the cope. These must match up with the flask used.

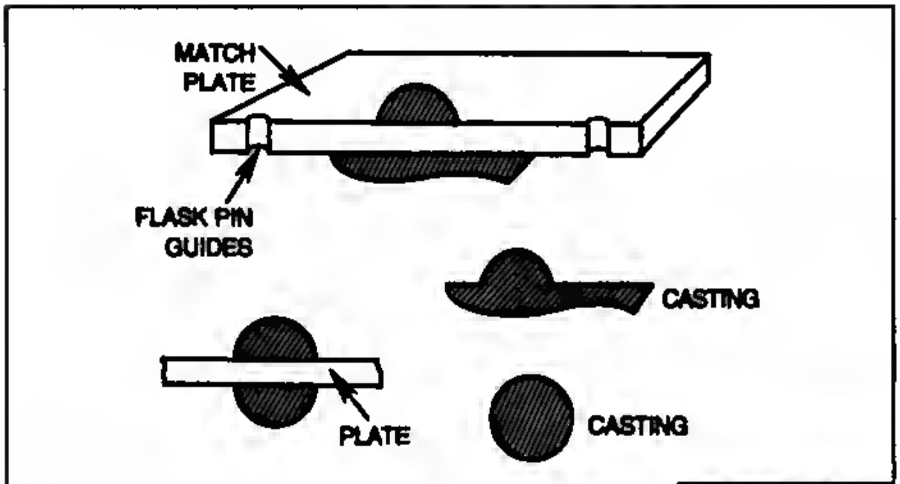

FIGURE 10.12

Match plate pattern.

The cope half of the pettern is ettached to the cope mount and the dreg pattern is ettached to the dreg mount. The cope and drag molds are produced separately and put together for pouring. The usual practice is for one molder to make copes and another to make the drags. Cope and drag mounts are quite common when making large and very large castings where e metchplete would be out of the question due to its bulk and weight. Cope and drag mounts are sometimes called *tubs* (Figure 10.13).

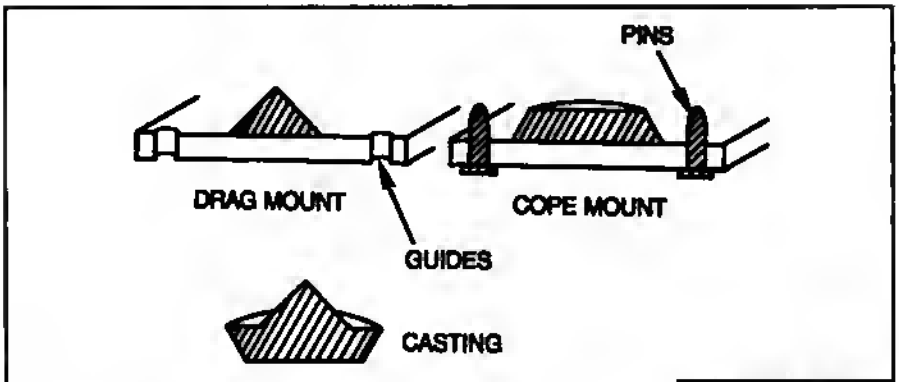

FIGURE 10.13

Cope and drag mounts.

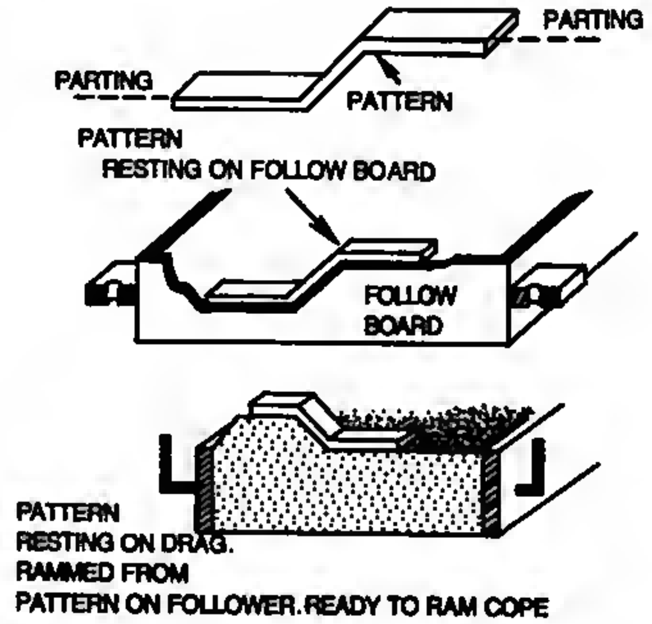

FIGURE 10.14

Follow board.

Follow Board

A board with a cavity or socket in it wbich conforms to tha form of the pattern and dafines tha parting surface of the drag is called a follow board. It can be mada of wood, plaster, or metal. When mada of sand it is called a *dry sand match*.

The pattern rests in the follow board while making up the drag half of the mold and in doing so establishes the correct sand parting. The follow board is removed, leaving the pattern rammed in tha drag up to the parting. The cope then takes the placa of the follow board and is rammed in the usual manner (Figure 10.14).

A simple follow board might consist of a molding board with a hole in it to allow the pattern to rest firmly on the board while tha drag is rammed (Figure 10.15).

Miscellaneous Patterns

When several different loosely gated patterns are assembled as a unit to be molded in the same flask, this arrangement is called a *card of patterns*.

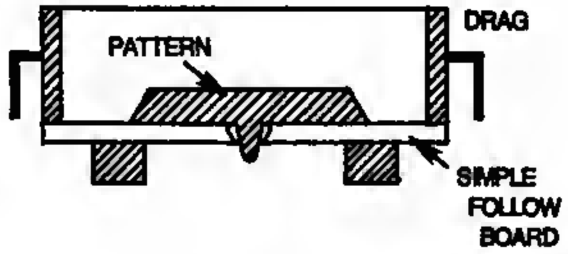

FIGURE 10.15

Simple follow board.

A *sweep pattern* consists of e hoard having a profila of the desired mold which, whan revolvad around a suitahle spindla or guide, produces that mold. Two are usually required. One sweeps the cope profile and tha other tha drag profila (Figure 10.16).

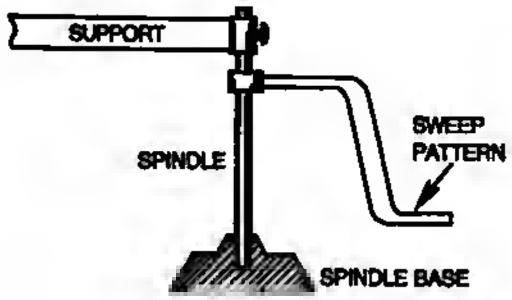

FIGURE 10.16

Sweep pattern.

Tha *skeleton pattern* is e framework of woodan hars which represent tha intarior and axterior form and tha matal thicknass of tha required casting. This typa of pattern is only used for huge cestings (Figure 10.17).

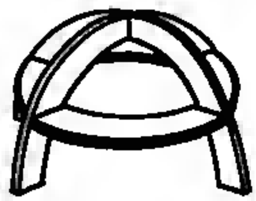

FIGURE 10.17

Skeleton pattern.

An *expendoble pottern* is when tha pattarn is lost. Expandabla pattarns for sand casting are styrofoam. They ara shapad to the desired form with attached styrofoam gates, runners, and risers. Tha styrofoam pattarn is moldad with dry clay-frea sharp silica sand in a hox or steal frame. The pattern is vaporized by the metal poured into tha mold, leaving tha casting.

Wood Patterns

Wood patterns used for cesting are given several coats of orange shellac to which a pinch of oxalic acid has bean added. This gives tham a waterproof, smooth, hard surfaca.

QUICK TIP

A white pine pattern that weighs 1 pound, will produce an aluminum casting of 8 pounds and a brass casting of 19 pounds.

The majority of wood patterns are mada of white pine (sugar pine) as it is easily worked and, when shellacked properly, will not warp under ordinary use.

The approximate weight of a casting can be determined by weigbing the wood pattern and multiplying by the appropriata factor indicated. Aluminum 8, cast iron 16.7, copper 19.8, brass 19.0, steel 17.0.

Mounting Patterns

The brass plata method of transfer is an old one and, if dona with enough care, usually will do a good job. It is my opinion, however, that the use of a suitable transfar frama or flask and plaster is by far tha aasiast mathod of gatting a closa match.

This system is simpla, cheap, and pretty close to foolproof (Figuras 10.18 through 10.20). Taka a 12 × 18-inch flask, for example, and mount pattarns on a plate for usa in it. Ramove the bushings from both ends of the cope and rebush tha flask with tight, round bushings. Allow only about 0.003-incb clearance batween tha pin and bushing.

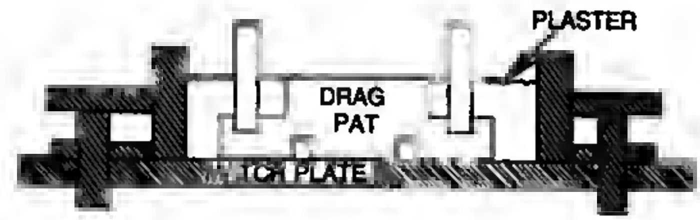

FIGURE 10.18

To mount a pattem, drag the pattems, plug mounting holes, and pour the plaster.

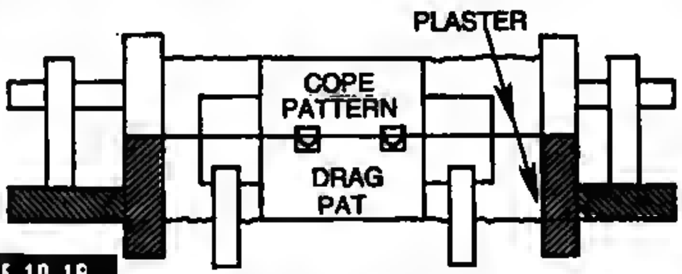

FIGURE 10.19

The second step in mounting a pattem includes removing the plate, fitting the cope pattems to drag pattems and pouring the cope plaster.

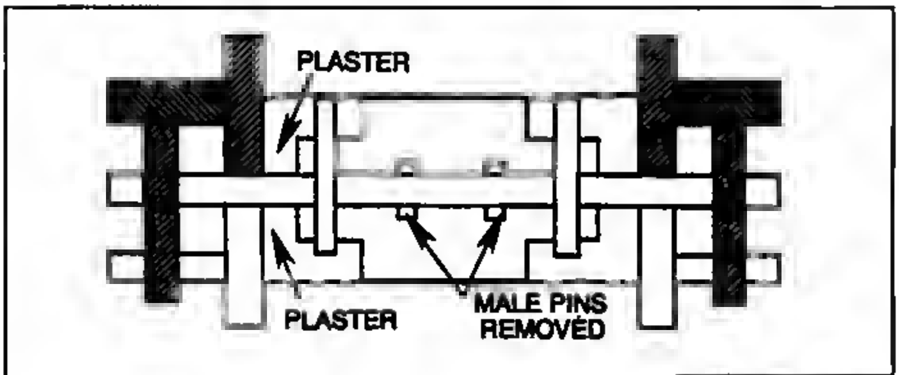

FIGURE 10.20

The third pattern mounting step involves removing halves of flask containing plaster, patterns, and plate plugs. Then drill the mounting holes.

Alternatively, you can design, cest, and mechine e speciel eluminum flesk with a close fit between the pins and the bushings.

Finish the petterns in the usual manner, pinning them together as if you were going to use them for loose molding, with one exception. In the dreg-helf petterns, drill suiteble holes through the prints, etc., to mount the petterns to the plete in the finel steps. Next, fit e suiteble 12 × 18 inch eluminum plete to the doctored-up flesk with suiteble pin lugs. Hold these pin lugs also to a close tolerance—0.003 inch or so clearance between the lugs and the pins.

Place the cope and dreg flesk together, with the plete between them. Turn the entire rig so thet the dreg side is up. Locete the dreg patterns on the plate where you want them with respect to gating. Glue them in place with shellec or wax. Place suitable dowels in the holes you drilled for use leter during mounting. These dowels sbould stick up out of the pattern not less than an incb or so.

With the dreg patterns properly loceted and stuck down to the plete, and with plugs or dowels in the mounting boles, piece e weight on eech corner of the flesk. To the surfece of the plete and petterns, apply a good commercial plester release. Pour enough plester into the drag flask to fill it to a depth which will give e good coverage around the petterns, yet leave the dowels sticking through the plester.

After the plaster has set, remove the plete and the drag half of the flask from the cope helf. Apply a little heat to the bottom of the plate to loosen the wax or shellac and remove the plate. Should the patterns come out of the plester in the dreg, simply remove them from the plete and reset them in their respective cavities. The drag is then turned

over on its back, parting face up. Clean off petterns and top carefully. Plece the cope balves of the petterns over their mating halves. They ara embedded to the parting line in plaster in the drag of the special flesk. Place the cope on the dreg, weighing all four corners with e suiteble weigbt.

Apply e plester parting or plester release over the entire surfece of the plaster and the cope balves of the patterns. Tben pour sufficiant plaster into the cope to give good coverage around the cope petterns. Beceuse you beve no dowels to worry ebout, you can cover the petterns up. Part the two flasks. The cope balf will contain the cope balves of the petterns and tha drag helf will contein the dreg belves.

Next, return to the aluminum metch plete fitted with suitable lugs and replece the cope half. Roll the wbole works over to bring the dreg up and clamp all four corners. Tha clamp sbould extend from the cope or top of tha flask to tha bottom of tha drag half. With the flask in the upside-down position, remove the plugs or dowels in tha holes for mounting. Leeving these holes open, take the wbole business over to the drill press and drill through tha drag petterns, the plata, and the copa. Chip tha plastar away until you get down to tha pattarn. Then driva pins through or screw them down. There are many varietions of this method, but this is the basic principle. Remove the special flask and the plester, laaving the patterns with a very close register. Also remove the special lugs from the plete and mount whetever type of lugs you are using.

This rigging, done in the same manner, is suitable for making cope and dreg mounts. It also will work in the mounting of e symmetrical metch wben the flesks are fitted up with e pin on one end and e bushing on tha opposite ona. This is tha typa of equipment used on a pin-lift or stripper. The first half off, the dreg, is turned end-for-end, and the second half becomes the cope. It is used in some plumbing shops es well as in bobby sbops wbicb engage in the production of smell and medium castings. Tbe plester transfer system for mounting these symmetrical matches is used widely in this type of work.

Although e new 12 x 18-incb steel flesk that hes been rebusbed can be used, I would recommend that you construct e special pettern-mounting frame. This frame, or pair of frames, sbould be mechined up very accurately in a tool and dia shop. Spacial pins and bushings can be mede, and you will find this equipment to be more suiteble.

In most cases you require only ebout 2 or 2½ incbes of depth per section since it is not necessary for the plaster to cover the entire pattern. Only enough plaster is necessary to grip the pattern and bold it

in position until it is mounted firmly to the plate. When mounting patterns on cope and drag plates, be sure that the cope frame and drag fit accurately, that the drag frame fits the drag plate, and that the cope frame fits the cope plate. In the case of cope and drag mounts with an elongated or slotted hushing on one end, the hushing must be removed and replaced with a round busbing during the pattern mounting procedure only. It later is replaced with the original busbing.

There are many variations of the plaster transfer method and with a little fiddling around you might come up with something more suitable to your particular operation than the foregoing method. However, this is the basic procedure. Whether the patterns are pinned or screwed to the plate is a matter of individual preference.

In my opinion, it is poor practice to drill patterns prior to mounting on plates, tap out the drag balf or cope half of the pattern, mount the pattarns hy drilling oversized holes through the matchplate, and rely only upon tha screw wbicb passes through the cope balf of the pattern and the plate and into the drag half of the pattern.

I have had experience with clamping patterns together and with the screw method. I also have drilled through the two halves of the patterns and mounted the patterns across from each other on a matchplate by driving a pin through the hole and an oversized bola in the plate and into the remaining half of the pattern. If by chance the drill does run off, however, the farther the patterns are separated, the greater the mismatch will be.

With the plaster transfer method, however, it doesn't make much difference wbich way the drill goes as long as the patterns are secured tightly to the plate prior to the removal of the plaster. Tbe plaster will bold patterns accurately across from eacb other during the drilling, tapping, or pinning operations. Any type of method for mounting can be used in conjunction with plaster.

The accuracy of this system depends entirely upon how accurately and closely your transfer frames fit up.

Recessed Pattern

When molding a pattern with a deep recess in the cope side of the pattern, even if you don't come up quite straight with your draw and a section of the green sand stays down, you can often still retrieve and save the cope.

In many cases this problem is causad by improparly tampered molding sand and you will find that the sand is dry wbere the drop broke loose from the cope. A sticky pattarn may also be causad by low green strength and soft ramming, or the pocket is too deep or heavy to come up with the cope.

Regardless of tha cause, thare are two ways of saving tha copa. Put tha copa back on and roll tha mold ovar. Draw tha drag off, laaving tha drop resting on its mating surface. Now push a large headed nail carefully into tha sand to pin the broken piace to its mate. Turn the cope over and see if you bava dona a good job. If tha pieca that stayad down is not too large, the next best bet is to dampan both surfaces with a bulb sponga and sprinkle tha surface of tha sand piece in tha pattarn with wbaat flour. Put the copa back in place and strika directly ovar tha problam with tha butt and of tha rammar. Allow a second or two for your flour glue to stick, then draw tha copa, roll it ovar, and nail it. In either case, ba sure to patch or slick tha junction of tha rapair.

Glossary

A

abrasives Any material for grinding, polisbing, blesting, etc. Tbe field of ebrasives runs from a very mild ahrasive sucb as *rottenstone* or tin oxide to higbly ebrasive diamond dust, or grit. Netural ebresives include talc, sand, pumice, emery, corundum, garnet, diamond, etc. The manufactured ebrasives are silicon carbide, eluminum oxide, metellic shot, and grit. The forms are es many es the types of ebresives—sandpeper, grinding wbeels, rouges, etc.

acetylene A colorless gas HC:CH. It is used es e fuel in bigh temperature torches sucb as the oxygen/ecetylena welding and cutting torches. Pure ecetylana has a swaet odor but when contaminated with hydrogen sulphida it smells quite bad. It is easily generated by the ection of water on calcium carbide. It is sold in pressure tanks, celled *bottles*, dissolved in ecetone to render it nonexplosive. One voluma of ecetone will ebsorb or dissolve 25 volumes of ecetylene. It is used to produce other cbemicals. Large users often produce their own with a davice called an *ocetylene generator*. It consists of two cbambers, ona abova the other. The top chamber contains dry calcium carbide. The bottom chamber contains weter. Tbe carbide is dispensed into the weter by a pressure-regulated valve, or gate, when e predetermined ecetylene ges pressure is reached by the reection in the bottom chamber. The valve closes, preventing any more carbide from entering tha weter. When the pressure drops due to tha use of the ecetylene from tha bottom chamber, the velve opens and tha process is repeeted.

In Sweden during World War I, some eutomohiles were operated on ecetylene gas. Presto-O-Lite™ Union Carbide Co. is the trade name for acetylena dissolved in acetone.

acid Ceramic refractory materials of a high melting point consisting largely of silice. Tbus steel melted in a furnace with an ecid refractory bottom under an acid siliceous slag is called *ocid steel*.

adjustable jackets A loosely cornered slip jacket wbich will edjust to the taper of the mold and efford e good close fit (Fig. A-1). A popular brand adjustable jacket sold under the name Wopper Jaw jacket is manufactured by Products Engineering, Cape Girardeau, MO.

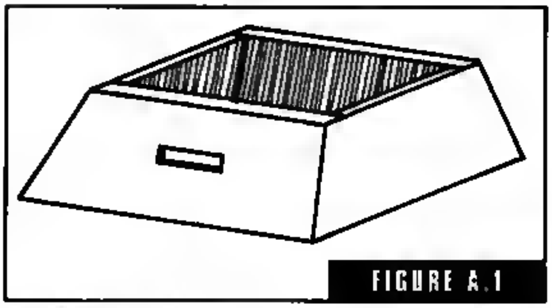

FIGURE A.1

An adjustable jacket.

aerators Any device whicb fluffs up and introduces eir into a molding sand to increase the flowability and rammability of the sand (Fig. A-2). It also helps to evenly cool and distribute the moisture. Simple riddling of the sand accomplishes this evenness to some extent. Some macbines condition and aerate the sand in the same action. A device widely used in the foundry is the Royer Sand & Blender machine. This mechine separates, aerates, and blends all in one action. Royer elso produces many types of aerators and conditioners.

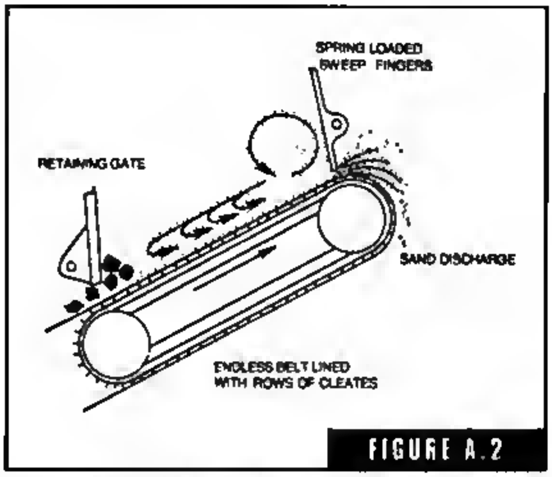

FIGURE A.2

An aerator. The refuse falls at the retaining gate.

Most mullers heve an eeretor et the discharge snoot whicb consists of e series of knives on a high speed sbaft. The sand being discharged must make e trip through these wbirling knives, wbicb eerete the sand. Some macbines consist of steel brushes rotating at high speed through whicb the sand must pass. Tbe process is called *oerating.*

Originally patented in 1910, the cleeted-belt eerator wes introduced to the foundry industry by Royer and was quickly accepted for conditioning sand. Over the years, the design, construction, and materials of the unique macbine bave been continually improved. The besic aeretor has been adapted to meet the industry's ever-increesing requirements for proper sand preparation. The development of new aerators for foundry applications continues to be an on-going process. Royer manufactures a variety of standard aerators: basic stationary and portable units, with or without magnetic cleaning; eerators mounted in bucket

elevators; belt-mounted aerators; aerators for feeding automatic molding machines; and aerators on molder's hoppers.

As sand is charged into a Royer Aerator, it falls on an inclined, endlass halt which bas rows of closely-spaced alloy-stael cleats. With the helt moving at more than 100 fpm, the cleats tear apart lumps and propel the sand up the belt to a *sweep*—a row of flat spring-loaded fingers mounted above the belt at the bead pulley. As tha sand churns against the sweep, trapped gassas are relaased and foreign materials, such as wedges and cores, fall to the lower and of the belt. The tumbling-cburning-mixing action on the helt aerates and cools the sand. Granular sand, hetween the rows of cleats, passes under the sweep and is thrown forward. Tbe stream of free-flowing sand continues to cool as it is discbarged into the air. This is called the basic cleat-belted principle.

The pattern of cleats, speed, and inclination of tha halt and spring tension are hasic dasign parameters. Tbe clearance batween the sweep assembly and tha helt, bowever, can be adjusted to achieve the desired degree of aeration. Capacity is datarmined hy the width and length of the belt and the condition of the sand.

A.F.S. clay American Founderman's Association dafines clay as the earthy portion of a foundry sand which, when suspandad in water, fails to settla at a rate of an incb per minuta and consists of particles less than 20 microns (.008 incb) in diameter—a combination of true clay and silt.

A.F.S. grain distribution Tbe distribution in percent of various sizes of grains in a givan sand establisbed by running a sample through a standard set of screens and waighing the sand retained on each screen. Tba distribution is than axpressed on a graph (Fig. A-3). Sand with 70 to 80 percent retained on thrae adjacent screens is considered ideal.

age hardening The property of some farrous and nonferrous alloys to increase hardness and strength by time alone at room tempärature. Tenzaloy™ Federated matals is a popular aluminum casting ingot which has very good properties of age bardening. Tha normal composition is copper 0.6 percent, zinc 7.5 percent, magnesium 0.4 percent, and the remainder aluminum. Cast aged one day at room temperature has a tensile strength of KSI 29. After 10 to 14 days the tensile jumps to KSI 35. The Brinell hardness (500 Kg) jumps from 60 on the first day to 74 about two weeks later. Permanent mold cast Tenzaloy tensile goes from 30

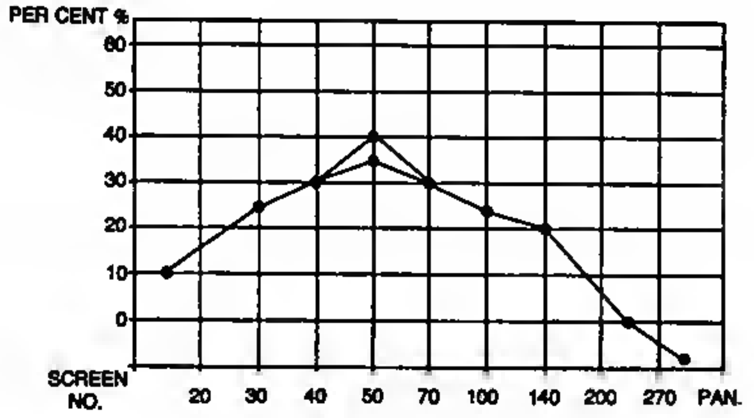

FIGURE A.3

A.F.S. grain distribution.

to 40. Some soft metels (leed bese) go the other wey, losing strength with age.

air belt The belt surrounding the cupola or hlest furnace which receivas the air from tha blower and evenly distributes it to the *tuyeres*. Also callad *bustle pipe*.

air dried A green mold or core wbich is ellowed to dry neturelly. Some bonding cleys used in green sand molding gain strength after the mold has air driad. This increase in strength is called *oir set strength*. Holloysite cley from Utah has this property dua to its lath-shaped structure. Also known es *white clay*.

air floaters Any dry compound thet is eir floeted or cepeble of floeting in the eir—fine dust, etc. Compounds of pitch, dry parting, blecking, cleys, and flours thet are edvertised es floatars or air floaters indicata thet they ara free from any beavy particles. Tbey are lightweight, usuelly of e fine uniform size, and free from tramp meterial.

air furnace A reverberetory type of furnece. The metal is melted on a shallow hearth by the flame from the fuel burning on one end of the bearth pessing over the hath on its way to the steck at the other end. Tbe beet is reflected from the roof and sidewells. Air furneces are fired with natural gas, oil, and pulverized coal or coke. Tbe passive air furnece is fired by a natural draft pulling the products of combustion ecross the bearth. A shallow bath is necassary in order to bring the hath tempereture up bigh enough.

A deep bath will not melt properly due to beat convection through the bearth bottom.

Tbe air furnace is widely used in the production of malleable iron. It is bard to control e cupole to produce malleeble by itself, but is a fast and efficient method of melting. Very often the metal is melted in e cupola and then tapped into the air furnace for refining to the correct analysis. This process is referred to as *duplexing*. The air furnece is e close cousin to the *open hearth* furnece.

With the older, more pessive air furneces that used coel burning on e grate, it was quite common to use e blower for forced draft along with the *stock droft* (suction). A pulverized coal burner bes taken the plece of these old jobs. A smell air furnece burning coal the old wey with some air assistance is e greet melter for the beckwoods or bobby foundry for ferrous or nonferrous melting. Tbe eir furnece is usually provided with e breest and tep hole on eecb side and is tepped like the cupole. Beceuse you beve e rether large metal surfece exposed to the products of combustion (unlike e crucible), greet care must be exercised as to the conditions of combustion or you can wind up with e bighly oxidized melt. Tbis is true of any open hearth air furnece of the small ferrous type and of the nonferrous reverberetory furneces whicb beve come into popularity.

air hardening When certain alloys of steel are cooled in air from e temperature ebove or higher than the transformetion range to room tempereture and remein bard, they are known as *oir-hordening olloys* or *self-hardening steels*. Metal lethe tool bits are self-bardening steel. Tbey are extremely difficult or impossible to anneal.

air hole Ges holes. Air or gas trepped in the cesting during solidificetion. Tbe major ceuse of *gos porosity* is ges ebsorption by the metal from the products of combustion: sulpbur dioxide, bydrogen, and oxygen. The least likely ceuse is e too-bot pouring tempereture.

airless blasting The cleaning of castings by throwing sbot or steel grit against the objects to be cleaned. Similar to sand blasting (Fig. A-4). Tbe basic difference is thet air is not used to propel the ebrasive. The ebresive is thrown by e bigh-speed impeller wheel. The sbot or ebrasive is fed through the bub of the impeller wbeel wbere it is picked up by the throwing bledes. It is eccelerated as it pesses to the peripbery of the wbeel and is thrown et bigh velocity. Tbere are variations of the machines but the principle is

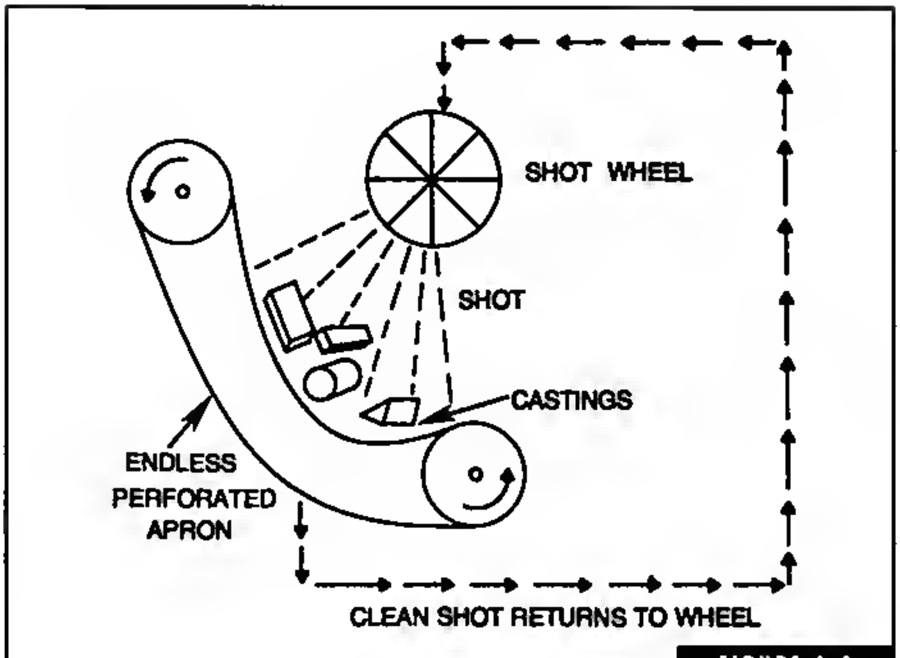

FIGURE A.4

Airless blasting.

the same. Some are continuous and the castings are carried througb the blast chamber in one side and out the other. Some of the castings are placed on rotary tables in the chamber and others are rolled back and forth on an endless apron conveyor (metel or rubber) whicb tumbles the castings under the blast of abrasive. The abrasive falls througb the perforations in the apron and is conveyed back to the wheel via a screw and bucket. Along the way back to the wbeel, the sbot or grit is cleaned of any sand, dust, etc.

air pocket (permanent mold) A defect known as an air pocket caused by trapped air or gas in the mold cavity. Found with permanent molds as well as with die casting. First it bas to be determined if the pocket is caused by a low pouring tempereture; by pouring incorrectly (too slow, bubbling, etc.); by the gating system not being properly designed; or by the mold not running bot enough. Wben you heve eliminated all of these possibilities, then the mold must be vented.

air rammers A rammer operated by air introduced into a cylinder which drives a reciprocating piston and rod (Fig. A-5). A rubber butt or peen is etteched to produce a fast rapid blow. Widely used

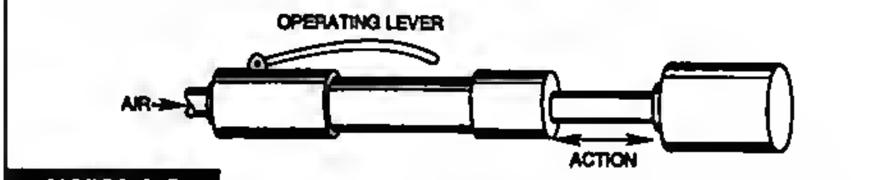

FIGURE A.5

Air rammer.

for bench, floor molds, and in the ramming of cores. Tbey range from small bench rammers to heavy floor rammers.

air strength When a green sand specimen is allowed to stand for any length of time and air dry before it is tested for its compressive strength, the air strength will bave increased. Tbe difference between a sample tested before and after air drying gives the foundryman an idea of what happens when a mold sits for a length of time and air dries prior to pouring. The increase in strength varies widely depending on the type and kind of clay used as a bond. Most foundrymen pay little attention to the air strength of their molding sand and are puzzled about dirt inclusions in the casting, whicb they attribute to dirty molding. Tbe problem could be simply that the sand is too low in air strength. During air drying, sbarp edges lose strength and crumble off or wasb off into the mold cavity. A simple change in clay bond can prevent the problem. The moisture content also plays a part in the loss or gain in air strength of the sand.

air vibrator Any pneumatic type of vibrator (Fig. A-6). There are two basic operating principles. One is the free piston type where air is introduced into the cylinder and the piston shuttles back and

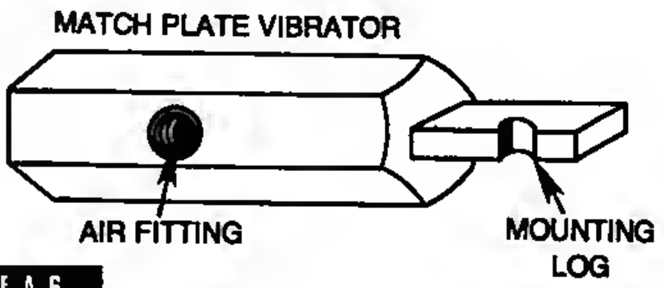

FIGURE A.6

Air vibrator.

forth at bigh speed (a floating piston air engine). The other is the ball type, where a steel ball traveling in a case producas tha vibration. The most common type used in the foundry is the *motch plote oir* (piston) vibrator. It vibrates tha pattern to ensure a clean lift of the copa and the pattarn.

Albany sand A naturally bonded sand from the district around Albany, Naw York. This sand was strip mined for years and yaars in various grades suitable for light aluminum casting to coarse grades for haavy gray iron. The field is pretty well worked out of good quelity grades. Synthatic molding sands bave just about replacad tha usa of naturally bonded sands. *Naturally bonded sonds*, howaver, can ba found practically anywbere in tha United States. As mined, they contain sufficient clay bond and tha corract propertias needad to make molds.

alkali metals 1A of tha pariodic tabla including lithium, sodium, potassium, rubidium, cesium, and francium.

alkaline metals Calcium, strontium, barium, radium, and tha group 11A of tha pariodic tahla.

allotropy Tha occurrence of an elemant in two or mora forms such as carbon which occurs in natura as diamonds, soft graphita, and amorphous coal.

alloy A comhination of metals melted togathar. If you taka 85 pounds of coppar, 5 pounds of tin, 5 pounds of lead, and 5 pounds of zinc and melt them together, you'll bava an alloy known as *red brass*. Also called *ounce metol*, it is an old and oftan used casting alloy. With 50 parcent lead and 50 parcent tin melted togather you hava tha common soft solder known as 50/50. Tbe percentages of the alloying elements vary to give you an alloy of a different nama and characteristic castebility, melting point, etc. If you took tha amount of laad and tin just describad (solder) and raised the percant of tin to 80 percent and lowered the lead to 20 percent, you would bave an alloy called *babbit*, a bearing metal. Raise the tin aven bigher to 90 to 95 percent and lower the lead to 10 or 4 percent and you'll hava *pewter*. Some matals or constituants ara not compatibla in any amounts other than a trace. Tha trace is called an *impurity*. From axtansiva metallurgical and pbysical tasting, the amounts of various metals in percents that will successfully alloy with eacb othar have been fairly well estahlished. The davalopment of new, useful, and sometimes sophisticated alloys are being researcbed and developed daily. For axampla, silicon

bronze, wbicb is an alloy of 3 to 4 percent silicon and the remainder copper is not compatible with lead other than as a very minor trace whicb is classified as a harmful impurity. Lead in even small amounts in silicon bronze combines with the silicon to form lead silicate (glass). When some element is added to an alloy in a minor amount to cbange the cbarecteristics of the alloy being produced, it is referred to as a *hordener*. Most babbit metal contains a small percent of antimony, whicb increases the hardness of the alloy considerably.

alloy cast iron Cast iron is composed of iron, carbon silicon, phosphorous, manganese, and sulpbur. Tbe elements which compose the alloy called cast iron or *gray iron* are used in different and varying proportions depending on the grade of cesting desired. Typical common gray iron would be approximately 93 percent iron, 3.25 percent carbon, 2.5 percent silicon, .50 percent manganese, .65 percent pbosphorous, and .10 percent sulphur. Sulphur is usually considered an impurity.

Alloy cast irons are essentially an alloy or iron and carbon to wbich an element or elements in various percentages and combinations are added. Sufficient amounts produce a measurable modification of the pbysical properties of the iron in the section (thickness and weight) under consideration. *Ferro alloys* such as ferrosilicon, and the nonferrous group phos copper, copper nickel, etc., are called *allaying elements*.

Some of these additives include chromium, silicon, molbydenium, vanadium, nickel, titanium, and phospborous copper. Tbese additions are usually added in the form of ferro alloys purcbased by the percent produced by smelting companies. More often than not the elements by themselves are difficult if not impossible to add as is from the pbysical element as well as the cost due to loss by oxidation. These additives are sold combined with iron in the form of sbot wafer briquettes with a percentage of the element combined with the iron. Thus if you purcbased 100 pounds of 50 percent ferrosilicon you would bave 50 pounds of silicon and 50 pounds of iron for eacb 100 pounds. When melting with the cupola, these additives are usually added to the stream of metal coming from the spout to the receiving ladle or to the pouring ladle; otherwise most of it would he lost if added to the cbarge in the cupola. In reverberatory, crucible, or induction

melting they can be edded directly to the beth. The term *innoculance* is used quite often for these additions.

alpha iron The form of iron characterized by a body-centered cubic crystal structure thet is stable below 1670 F. Carbon is prectically insoluble in alpba iron wben beated to e temperature above 1670 F. Tbe *ferrite* changes from alpbe to gamme stete, a fece-centered cubic form. *Gamma iron* reedily dissolves carbon. The solid solution is known as *austenite.*

alumel A nickel-based alloy used chiefly as a component in thermocouples.

aluminite An elumine refractory metariel.

aluminum A light metal produced from boxita wbich is not sufficiently strong enougb to be used to any extent commercielly. It is usuelly alloyed with silicon, copper, megnesium, nickel, and zinc in various emounts and combinetions to produce various pbysicel cbarecteristics like cestability, strength, soundness, etc., depending upon the method cbosen to cast, the cestings, and use. There are a greet number of elloys available (Teble A-1).

aluminum bronze A copper-basa alloy containing 5 to 15 parcant aluminum and up to 10 percent iron, with or without manganesa or nickel (Fig. A-7).

- Normel composition—88 percent copper, 3 percent iron, 9 percent eluminum.
- .276 pounds per cubic incb.
- Patternmakers shrinkage ¼ incb per foot.
- Pouring temperature: Light cestings 2050–2250 F., beevy castings 200–2100 F.
- Tensile strength, KSI 80.

Aluminum bronze is e difficult metal to cast due to its high shrinkage, sbort freezing range, and the tendency to form *dross* thet must ba trapped and prevented from getting into tha casting. Tbe same precaution on gating epplies to both small and large castings. The best method of *goting* is to introduce the metal into the bottom of the mold through an inverted *horn gote* (large end ettached to casting), using e *skimmer sprue* between the pouring sprue and the small end of the born.

TABLE A.1 Common AL Alloys.

	Sand Casting Alloys	
Copper 1.8% Manganese 1% Aluminum Remainder	Silicon 5% Aluminum 95%	Copper 4% Silicon 1% Aluminum 95%
Copper 4% Silicon 3% Aluminum 93%	Copper 4.5% Silicon 5.5% Aluminum 90%	Copper 3.5% Silicon 6.5% Aluminum 90%
Copper 4% Silicon 5% Aluminum 88%	Copper 7% Silicon 3.5% Aluminum 89.5%	Copper 6.5% Silicon 5.5% Manganese .3% Aluminum 87.7%
Copper 10% Mangesium .3% Aluminum 89.7%	Copper 10% Silicon 4% Magnesium .3% Aluminum 89.7%	
	Permanent Mold AL Alloys	
Silicon 5% Aluminum 95%	Copper 3% Silicon 6% Aluminum 91%	Copper 4% Silicon 3% Aluminum 93%
Copper 7% Silicon 5% Magnesium .4% Aluminum 87.64%	Copper 10% Magnesium .3% Aluminum 89.7%	
	Die Casting AL Alloys	
Copper 4% Silicon 8% Aluminum 87%	Silicon 5% Aluminum 95%	Silicon 9.5% Magnesium .5% Aluminum 90%

Risers should be one and a half times larger than the section they are to feed. Use large fillets and avoid sharp edges and a gating system that produces turbulence or a *nozzling effect*.

Keep the value of the moisture in the sand as low as possible. The top value should be 6 percent. Large castings should be cast in dry sand molds or no-bake molds. Any cores should be open and free from gas-producing ingredients. Keap flour to a mini-

mum. Use a simple oil sand core. Suitable green molding sand should be somewhere within these limits: permeability, 15 to 20; cleybond, 10 to 20; green strength, 5 to 10; moisture, 3 to 6 percent; and sand fineness, 100 to 150.

More often than not the weight of the risers will be equal to or exceed the weigbt of the casting. Heavy sections which cannot be readily fed should be chilled with edequete *chills.*

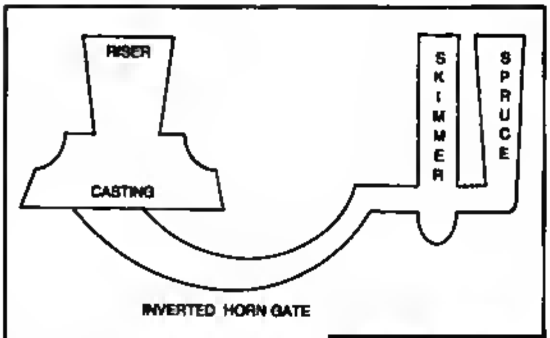

FIGURE A.7

Aluminum bronze.

aluminum flux Any meteriel, such es dry nitrogen or other inert gas, bubbled through the molten aluminum to rid it of ebsorbed gesses or steble metellic selts such as *zinc chloride* or *aluminum chloride.* In some cases e mixture of one or more *chloride, fluoride,* or *cryolite* with aluminum magnesium alloys. One or more alkaline earth salts are used as e flux. With clean metal and good melting prectices you can produce setisfactory cestings without the use of e flux. Consult your supplier for the recommended flux for the alloy you are melting and the type of melting equipment you are using. The simplest and safest way, whicb produces no obnoxious poison gas, is to simply bubble dry nitrogen gas through the molten bath.

aluminum nickel bronze When nickel is edded to aluminum bronze in the order of from 2 to 5 percent, you gain in strength, reliability, and corrosion resistance. Excellent stebility in structure during cooling from the casting temperature prevents the *self annealing* thet some bronzes suffer from if allowed to cool too slowly. It can cause deterioration in mechanical properties.

Typical aluminum nickel bronze is composed of copper, 83.0 percent; nickel, 2.5 percent maximum; aluminum, 10.0 to 11.5 percent; manganese, .5 percent maximum; and iron, 3.0 to 5.0 percent.

Aluminum Ni bronze is handled the same wey you bandle streigbt aluminum bronze as far es foundry practice is concerned with the exception thet the bigher the percent of nickel, the botter you must melt and pour. For example, with 12 percent nickel your pouring range jumps from 2350 to 2550 F. wbich is

TABLE A.2 Aluminum Solder Components

Soluminium (German) AL Solder	Mourays
55% Tin	80 to 90% Zinc
33% Zinc	3 to 8 Copper
11% Aluminum	6 to 12% Aluminum
Bureau of Standards Aluminum Solder	**Alcoa**
87% tin	95% Zinc
8% zinc	5% Aluminum
5% Aluminum	
Aluminum to Aluminum	
91% Tin	
9% Zinc	

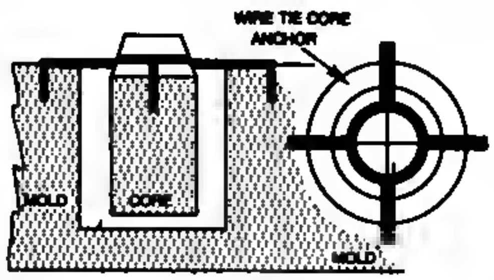

FIGURE A.8

Anchor core.

from 50 to 250 degrees ebove the freezing point with this much nickel. A common arror with all nickal alloys is pouring too cold.

aluminum pattern plate An aluminum plate for mounting wood or metal patterns (*match plate*) for molding. Plates ara produced in e wide variaty of sizas, thicknassas, and types. The common type is a flat parallal ground plata with ears to handla tha plate and ettach the lugs (guides) and metch plate vibrator (rapper).

aluminum solder For tha various componants and percentagas of aluminum solder, sea Table A-2.

ammonium chloride NH_4CL called *sal ammoniac.* Used as a soldaring flux for soft solders, a laad flux, and in brick form to clean soldering coppers and irons.

anchor (core) Any device used to hold or anchor a core in place (Fig. A-8). It could be e nail running through a print into the sand to anchor the core or e wire tie used when pouring an open-faced bushing mold. Tha anchor holds tha bushing cora down and centered when pouring without a copa.

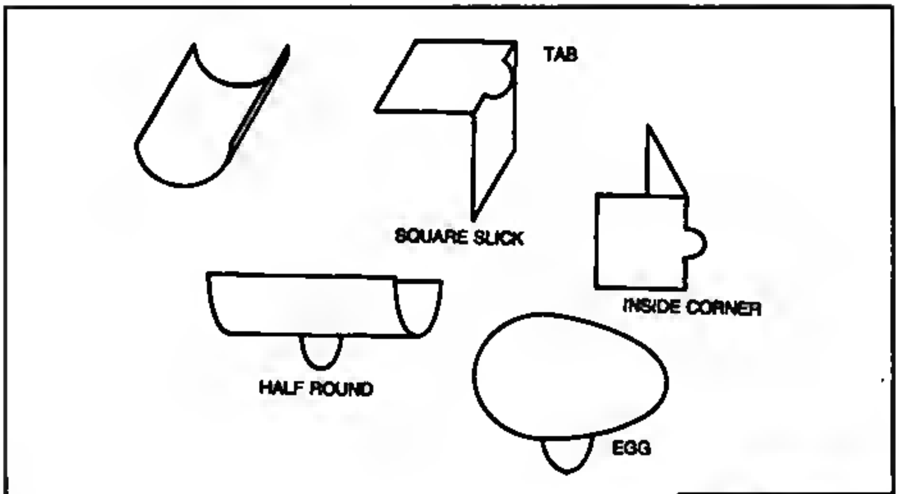

FIGURE A.9

Angle sleeker.

angle sleeker A molder's hand tool for smoothing or sleeking inside and outside corners of e mold (Fig. A-9). These sleeker tools have e helf-round teb on their heck surfece which is held between the thumb and first finger and used es you would e pressing iron to smooth the area you desire, especially when repairing e mold surfece. Avoid excess sleeking using too much pressure. This could compact the sand et the point of sleeking too tightly and result in e kick or blow et thet point.

angle stem chaplet A sheet metal cheplet with an open design to permit an edequate flow of molten metal through the cheplet (Fig. A-10). Insures proper burning in.

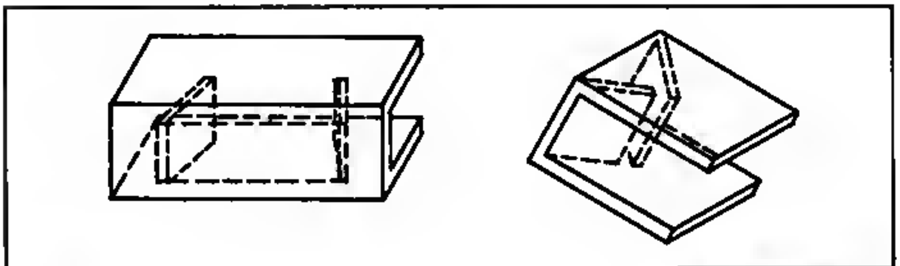

FIGURE A.10

Angle stem chaplet.

annealing The process of heeting ferrous metals ahove the *critical temperature*—temperature at which changes take place. critical temperatures are determined by liheration of beat wben the metal is beeted, thus resulting in halts and arrests on heating or cooling curves. The metal is held at the critical temperature until the transformation is complete. The metal is cooled slowly in a furnece or pecked in hone ash or cinders to cool slowly. The metal is then relieved of design and cesting stresses and is more ductile and easier to machine.

With copper hase and precious metals (gold, silver, etc.), the process is reversed. In this casa the metel is heated to its critical temperature—usuelly a dull red in the dark—and quenched in cold water.

anneal, malleable This heet treatment involves heating and then slow cooling. With regard to melleahla iron, it is the method usad to convert the hard hrittle iron castings into tough, ductile, malleable iron. This treatment causes the carbon in the white iron to precipitate in the frea stata in the form of tiny particles instead of flakes as in grey iron.

annealing pots Iron pots in whicb castings thet are to ba annealed or melleabilized ara packed to protect them from the furnace atmosphere during the annealing process.

antimony oxide An oxide of antimony. Its principal foundry use is as a hardener in leed-base alloys.

anti-piping compounds Carbonous (slow oxidizing) compounds which are sprinkled on the top of the riser to slow down the heat loss, kaeping the riser liquid longer so thet it can do its joh (Fig. A-11). Some are mildly exothermic or quite volatile like the old hot patch. *Insulating sleeves* of plester of paris, or other insulating materiels are sold hy foundry suppliers in a wida variety of sizes and meterials. Some are simply insulators, others are exothermic. Exothermic anti-piping compound materials are composed chiefly of wbat is known as *thermit*, but modified to react less violently. Tbermit is hasically a mixture of powdered aluminum and iron oxide.

The idea is to keep the riser liquid as long es possible. It ensures the proper feeding of liquid metal to the shrinking casting to promote directional feeding.

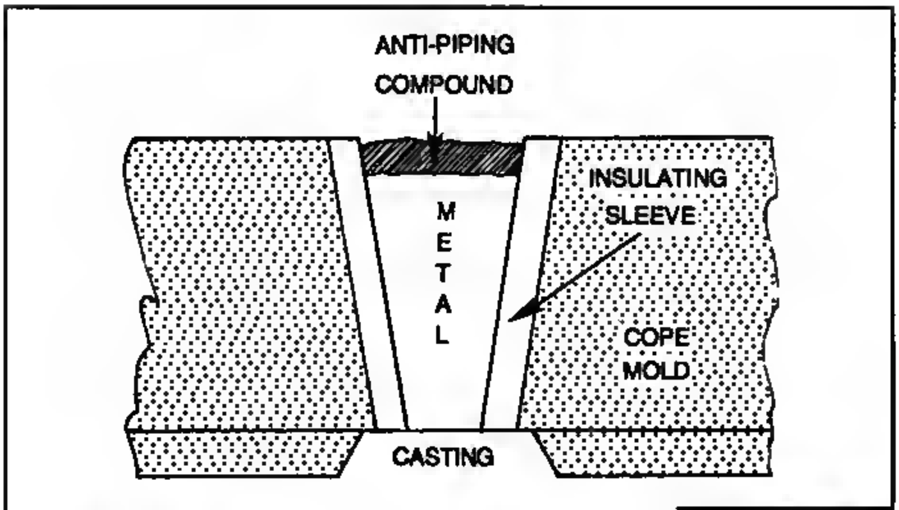

FIGURE A.11

Anti-piping compounds.

Anti-piping compounds should not be edded until the riser will take no more metal. They prevent the compounds from being fed into the casting. Anti-piping compounds and sleeves are widely used in steel and iron founding and to e smell extent in large nonferrous work.

arbor A metal (cast or fabricated) form used to support e dry sand or green sand core or mold body for strength (Fig. A-12). Also used extensively in heavy loam molding. Sometimes called a *crab*.

Arbors are usually mede to fit e particular job. A common use is in the casting of gray iron soil pipe fittings using green sand cores.

In prectice the core is mede in e full core box hy *booking*. The drag half of the core hox is partially filled with green sand and the arbor set in plece, then the half core completed. The cope half is then mede up and the box booked. The cope hox is removed and the core lifted out by the arhor, which supports it. The cope half of the green sand rests on top of the arbor and the drag helf, supported on the arbor by the half-round sections, extends into its body. The tip-tail fits into e print made in the drag mold by e print on the pattern. The tip tail does two things: It prevents the core from tipping over and touching in the drag and it locetes the core properly in the mold when the mold is closed.

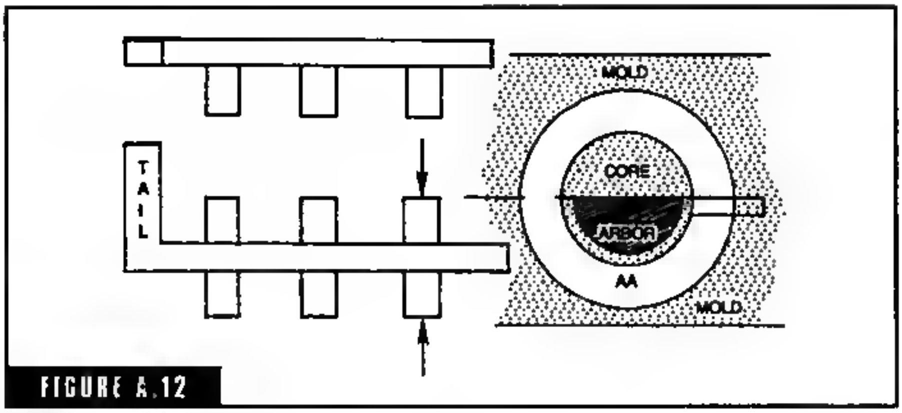

FIGURE A.12
Arbor.

Cores for large cylindrical castings molded borizontally are often swept up (or rammed) on e perforeted steel or cast iron core arbor. The arbor is first wrapped with burlep to prevent the sand from going through the vent holes (perforetions).

The pettern usually bes prints on it to accommodete the arbor es well as the core. Small bollow tin tubes are elso sold to strengthen e core section by ramming them up where needed wben making the core.

In comparison to the sculptured armeture, e core or mold arbor represents extre support and strength. In casting, it often serves several purposes all et the same time, such as creeting e peth for the core gases to escape through plus the conservetion of meterial. In investment cesting (full mold), steel tubing perforeted and wrapped with peper is used es e *core support* and *core vent*. More often than not it spells the difference between losing e casting from e broken core and e core blowing. Tbe unperforeted section, extending through e section of the mold which will fill with metal when poured, prevents the vent from stopping off and causing e blow. Steel eutomobile ges line tubing is excellent for this purpose.

arc fumaces There are two basic types in use—the *direct* and *indirect arc* (Fig. A-13). In the direct arc furnece three electrodes in e triangular pettern come through the roof of the furnece through suiteble openings. They are provided with e suitable mecbanism for raising and lowering them. The metal is melted by direct contact with the electrodes. Tbe electrodes are raised and the charge pleced on the bearth. The electrodes are then lowered and the

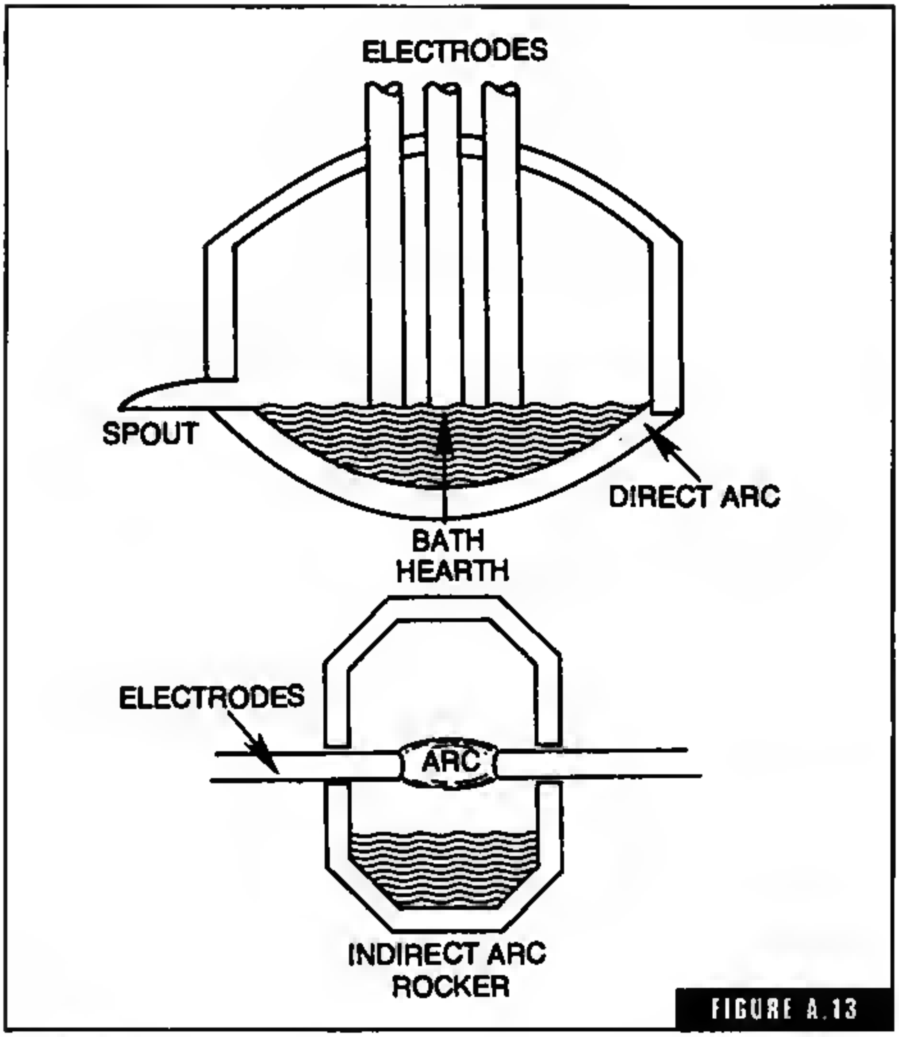

FIGURE A.13

Arc furnaces.

current is turned on. The electrodes melt their way through the charge nearly to the hottom. As the molten metal (beth) rises, the electrodes are raised to the correct height in respect to the beth. As soon as the correct refining period is reached, the current is reduced. The bath is refined and chemicelly adjusted in the furnece by various slag treatments (boils), oxygen lancings, ferro elloy editions (depending on what is called for as the final analysis), and the starting charge. There are direct-arc furneces as smell as 2 tons to 150 tons and larger. The furnace is tilted to remove the *heat* (molten metal).

In the indirect arc furnece the metel is melted by beet redietion of an arc struck and maintainad hatween two carbon alectrodes. The arc is maintained by an automatic screw feed thet edvances the electrodes to meintein the correct arc gap as the alactrodes ara consumed. The shell is barrel sbeped and rides on a set of rollars and is rocked heck and forward through an arc of about 180 degrees. This rocking motion performs the same function as a rotary furnece by carrying the molten metel over the beated lining in all directions, wbicb does the melting. Tbese furnaces are called indirect arc roteting furneces and *Detroit rockers*. Tbe arc does not come in contect with the charge.

Tbe mejor manufacturer of this type of furnace is Kuhlman Electric, Detroit. Tbe Detroit rocker is e popular nonferrous melting unit.

arch brick Taparad refractory bricks usad to construct a furnaca or kiln-arcbed roof. The two most common sizes are the Number 1 and Number 2 arch (Fig. A-14). By selecting the correct combinetion of straigbt brick, splits, and Number 1 and Number 2 arch brick, you can build the desired arch redius.

arsenic trioxide AS_2O_3, elso known es *white orsenic*. Used es an elloying ingredient in producing steel and edded to antimonial leads, elloys, and wbite metel bearings. Used as e hardener and to increese fluidity. Wben edded to copper, it increeses the anneeling tempereture for use es radietors. When added to laad it changes the surface tension and permits formation of perfectly spherical shot wben dropped from e sbot tower. It is usually colored pink to identify it es e poison.

artificial sand Silice sand made by grinding up silical rock and grading it.

atmospheric feeder Tbe theory bebind the atmospberic feeder is thet upon solidifying and shrinking, the casting forms a partial vacuum in the mold cavity (Fig. A-15). If e connection can ba made with the liquid metal in the riser (during this time and ection) to the etmospbere, the *otmospheric pressure* will assist in feeding the cesting and prevent *shrinkage cavities* due to leck of feed metal. It is a function of diffarential pressures. By plecing e dry sand cora extending into a feed riser or gate, you prevent the solidifying skin from closing the liquid metel off from the atmospbere, allowing the etmosphera to axert its pressure to assist in feeding the casting. This system is widely used in steel castings,

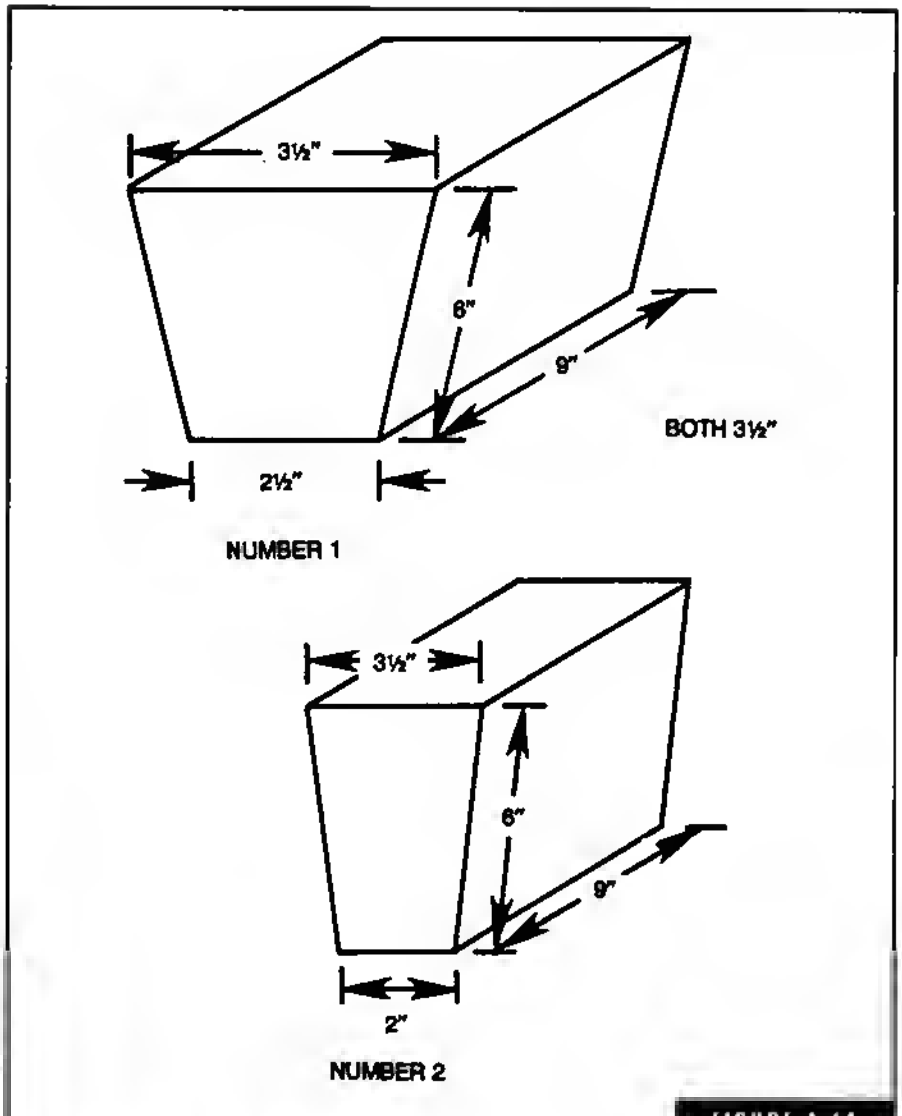

FIGURE A.14

Arc bricks Number 1 and Number 2.

and the euthor has bed great success with large manganese bronze castings using this method.

Tbis method is the principle behind *churning* e riser with an iron bar to effect feed. The object is to keep the riser open to the etmospheric pressure as long as possible. This system bas been the subject of several petents by the late George Batty, Henry Pbillips, and John Williams.

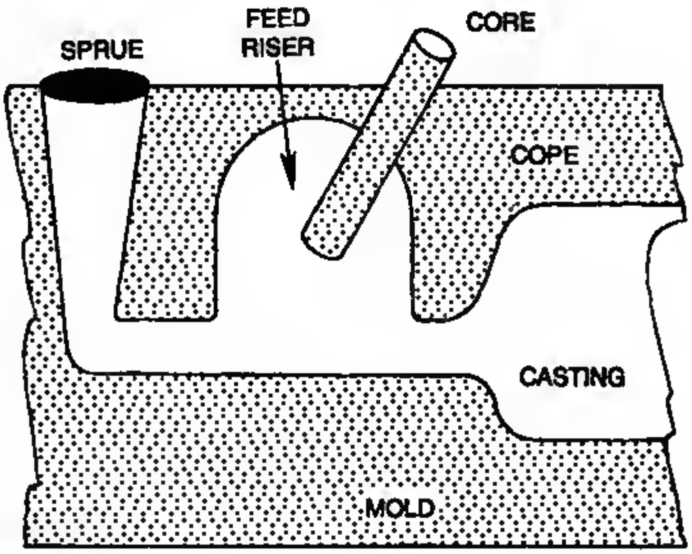

FIGURE A.15

Atmospheric feeder.

auto oxidation The principle behind the oil oxygen process of core making. It is a form of oxidation by which drying oils ahsorb oxygen and polymerize the oil to e solid. The process is eccelerated by heat and oxygen bearing materials—*perborates, percarbonotes*, and *peroxides*.

autogenous heat treating Shaking out the casting as soon es it has solidified, scraping off the sand, and letting it cool on the foundry floor in a dreft. The cooling can be speeded up with a weter spray.

autogenous welding Pouring hot metal into a defect in a casting in hopes it will weld and become part of the parent metal. This is also called *burning in*. It is a hit-or-miss deel et any rate. The hotter the cesting heing repaired the hetter chance you heve of estahlishing e good homogenous weld.

B

babbitt The original Babbitt, named after its inventor, was 88.9 percent tin, 7.4 percent antimony, and 3.7 percent copper with a melting temperature of 462 F. Used for machinery bearings. However, today there is a large family of tin base alloys called babbitt. Any white alloy used for bearings is currently called babbitt.

babbitt anchors A tin form filled with baked core sand used to cast an undercut cavity in a casting where a babbitt bearing is going to be poured (cast) (Fig. B-1). The cavity made in the casting provides a lock to hold the babbit in position. The anchors have metal springs to hold them in place in the green sand mold during casting. They can be purcbased in diameters from ¾ incbes to 1¼ incbes and rectangular from ½ × 1¼ × 3/16 inch deep to ⅞ × 3½ × ¾ inch deep.

back draft A reverse taper on the vertical surface of a pattern which prevents the removal of the pattern from the mold.

backing board A second bottom board used to lay the cope over on its back for removing a loose pattern, repair, etc.

backing sand Foundry floor or system sand used to back or complete a mold after the pattern is covered with a facing sand—new or finer sand, or a facing mix such as #10 facing. (One part sea coal, 10 parts new molding sand with or without an added binder such as *goulac*, wheat flour, etc.) In order to conserve sand and materials on large molds when molding with no-bake or CO_2 sand, the pattern is faced with the no-bake or CO_2 and set, then backed or finished off with floor sand.

baffle plate furnace A refractory wall in a fire box or furnace to deflect or change the direction of the flame (Fig. B-2). It is also called a *bag wall* or arcb baffle. In a reverberatory furnace it is installed at the far end just before the stack, causing the flame to swing back toward the burner or reverberate. In down-draft kilns it directs the flame and

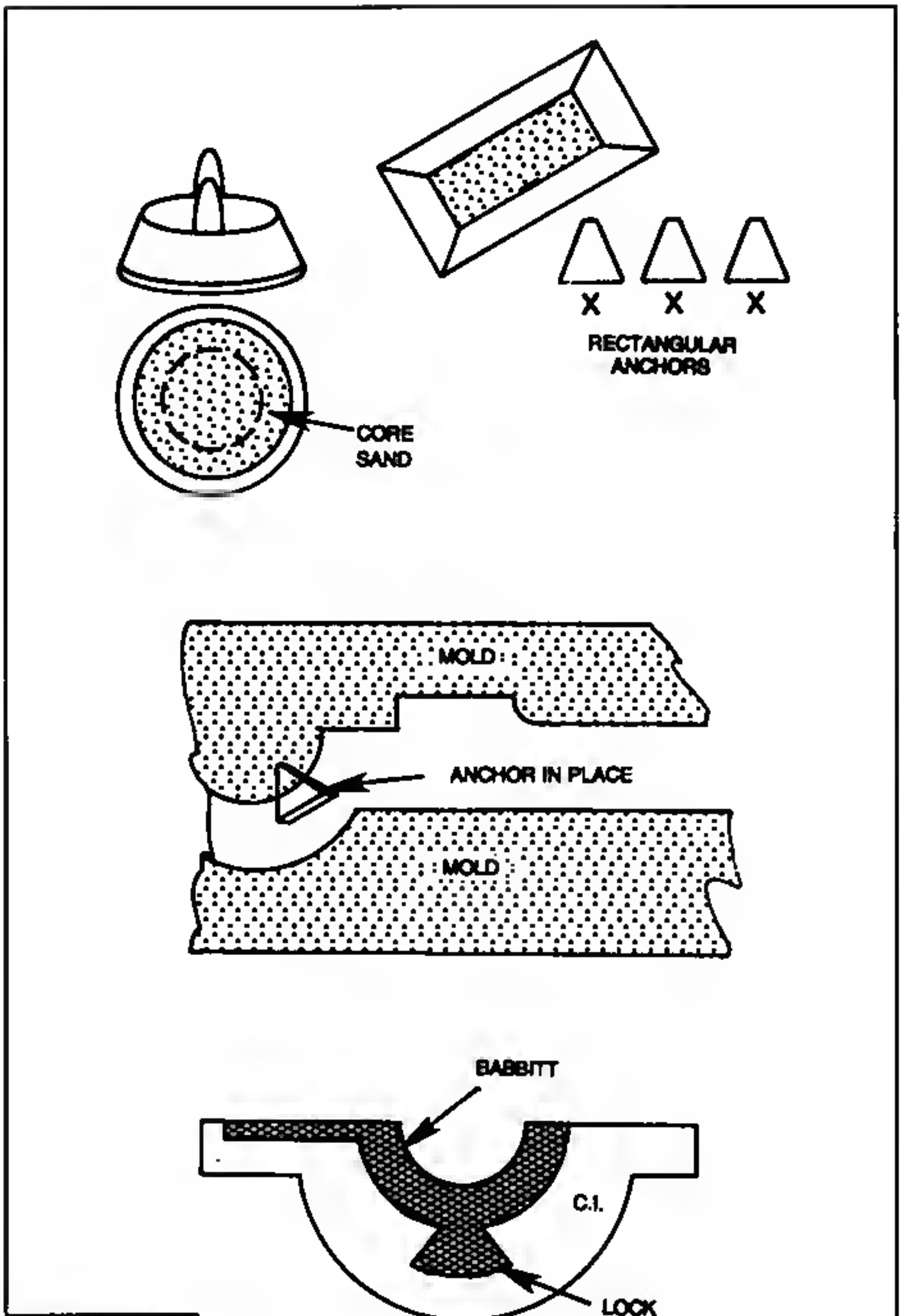

FIGURE B.1

Babbitt anchors.

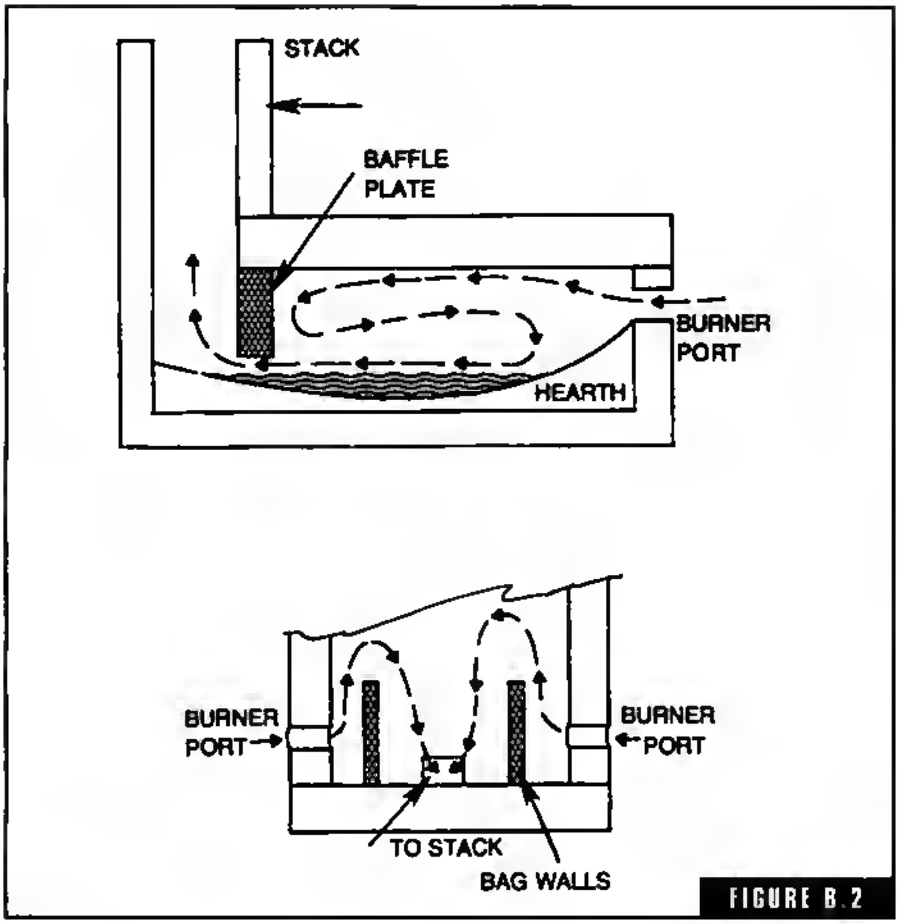

FIGURE B.2

Baffle plate.

heat upward into the arch to prevant it from heading straight out of the stack.

baffle plate pouring basin Baffle plates are sometimes used in a special typa of skimmar type pouring basin (Fig. B-3). This typa of runner basin is made up of a cast iron runnar box divided into four compartments. The theory is that each compartment allows the slag, dirt, and scum to float to tha top of the metal and gives the matal four chances to rid itself of foreign inclusions. When it reaches the sprue, you have only clean metal. The author has constructad various versions of this basin based on a skimmer with a continuous tapped cupola spout. I hava had graat success,

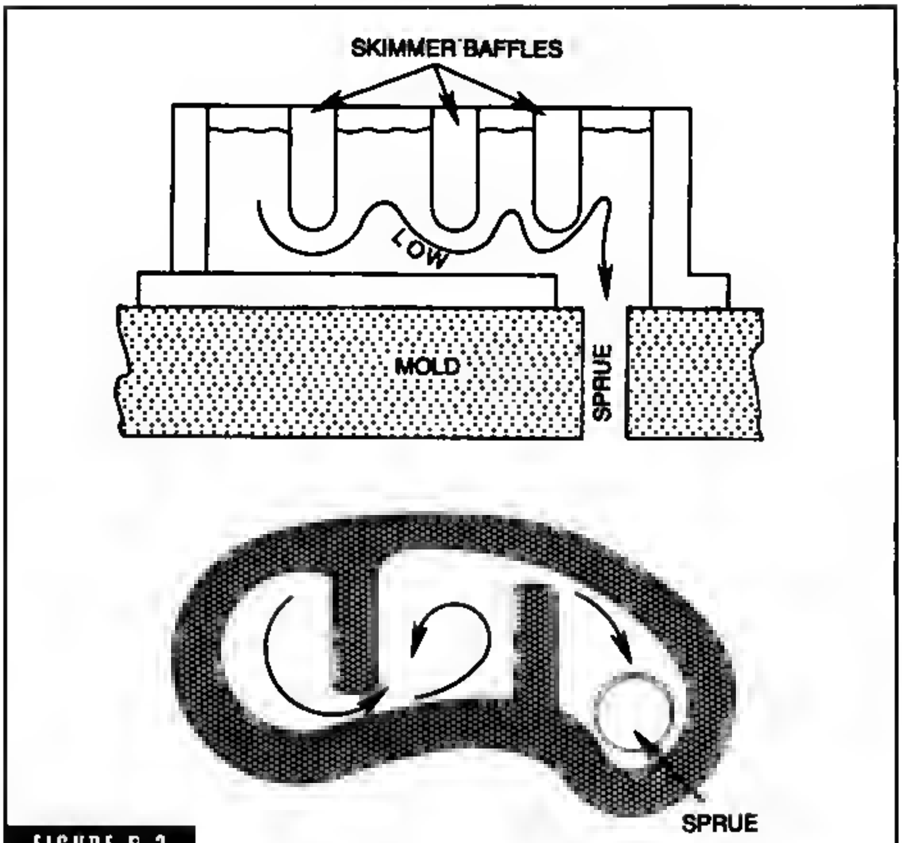

FIGURE B.3

Baffle plate pouring basin.

especially in pouring large gray iron and hronza castings. Tha cast iron runnar hox is lined with loam or monolithic rafractory material, hlackad, and thoroughly dried. The tima it takes to maka this type of rig is well worth it.

bag house A large chamhar for holding hags used in the filtration of gassas from a furnaca to recovar matal oxidas, fly ash, and othar solids suspanded in the gasses. In reality it is a large vacuum cleaner. The bags are made of various materials from cloth to high-tamperature caramic fihars. Aside from tha recovery of metal oxides which might hava a valua, the EPA requires a bag housa on many oparations as air pollution davices. Bag houses are usad alona or in conjunction with electrical precipitators and various washing devicas. Tha exhaust gasses usually have to ha

cooled down quite a bit prior to entering the bag bouse to prevent the bags from melting or burning up.

bail Tbe boop connection between a ladle and crane book (Fig. B-4).

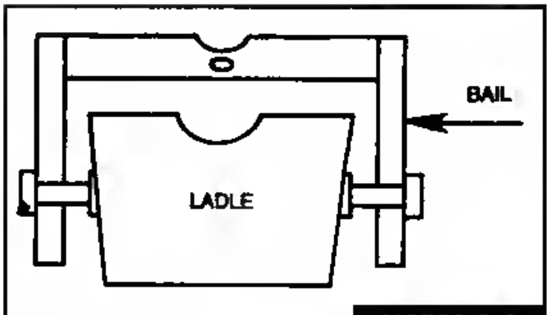

FIGURE B.4

A bail.

baked core A dry sand core that bas been baked to set the binder. A simple oil sand core must be baked et 350 to 400 F. to oxidize the oil and cement the grains of sand together. The core stays together during the cesting operation long enough for the metal to take a set. Tbe heat from the cooling casting breaks down the binder (burns it up), destroying its bond and allowing the core to collapse.

baked permeability Tbe property of a baked core cooled to room tempereture to pess through those gasses formed wbile pouring the molten metal into the mold. These gasses must be vented ewey from the casting through the core vents.

baked strength Tbe compressive, sbeer, tensile strength of a baked core or mold. A measure of its tenecity to e breaking force. The baked strength is far greeter than its green unbaked strength.

baking cycle Tbe time required to bake an oil sand core. Minimum baking cycle in a conventional oven ranges from a minimum of two hours to four to six bours. Tbis will vary with the mix, size, and type of core being baked. The cooling time sbould also be taken into consideretion wben planning a scbedule in order to beve cores to the molders on time. Everything must be considered—inspection, gluing, mudding, sizing, etc.

balance core A core with only one point of suspension or print (Fig. B-5). Tbe core print is made long enough to bave sufficient purchase in the mold to prevent it from moving during cesting.

ball mill A cylindrical device thet is revolved. It is partly filled with iron or ceramic (porcelain) balls for grinding or mixing sand or other materials. Widely used in hard-rock mining to reduce the ore-carrying meterials to a fine mesh to facilitate the removal of the ore. Ball-mill interiors are often lined with various abrasive-resistant meterials.

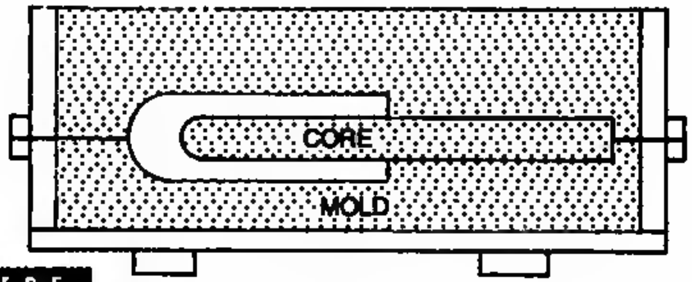

FIGURE B.5

A balance core.

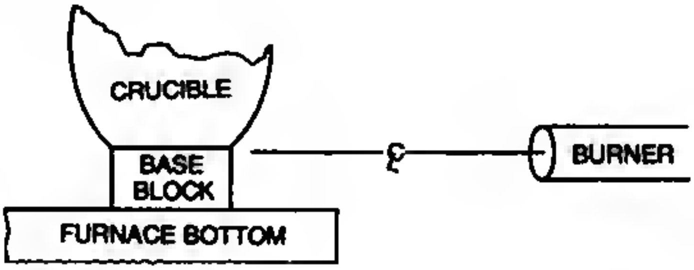

FIGURE B.6

The base block.

bank sand Sedimentary sand deposits containing less than 5 percent clay.

base block Also known as a *pedestol block*, the base block is used to support the crucible in the furnace (Fig. B-6). The bese block sbould be mede of the same material es the crucible and be the same diameter es the bottom of the crucible it supports—9 incbes in beight or of such height that the centerline of the burner is et the junction of the crucible and block.

base exchange of clay Cley type binders have the ability to excbange some of their ions with other cbemicals, such as methylene blue. When the bese excbange of e given clay is decreased so is its bonding power. Baroid Chemicals Inc. sells e kit used to determine the amount of effective sand binder in molding sands by methylene blue.

basic A chemical term referring to any material which gives an alkaline reaction. In e melting furnace with the innerlining and bot-

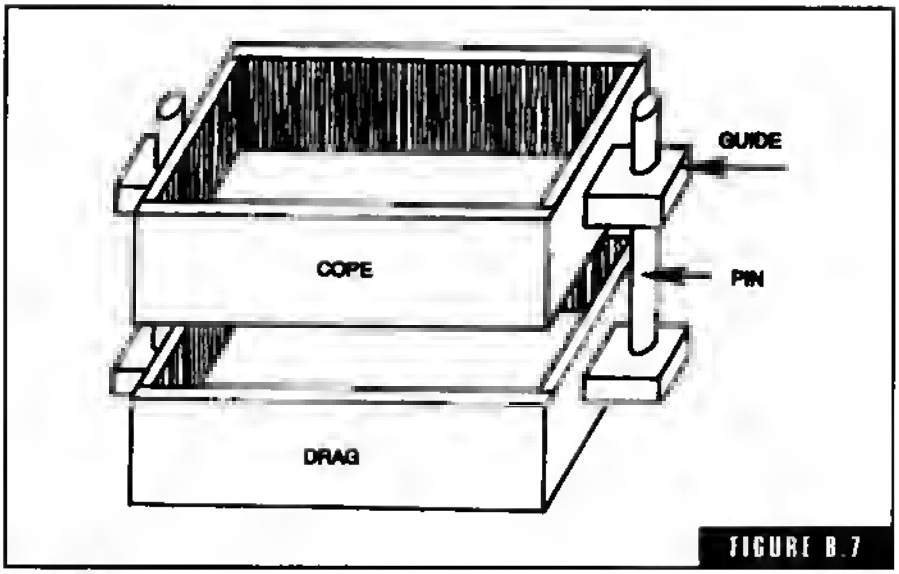

FIGURE B.7

Basic flask.

tom composad of a hasic matarial such as crushed and humed *dolomite, mognesite* or *magnesite bricks*, and using a hasic slag, the reection is celled *basic melting*.

basic flask The top frame of tha flask is callad tha *cope* and tha hottom frame is called tha *drag* (Fig. B-7). In soma molding oparations you need one or more sections between the cope and the drag. These sactions are called *cheeks*.

The pins and guides thet are used to hold tha sections togathar can he purchasad in a wida variety of types and configurations, round and half round, douhla round, and vee shaped. Single, douhla, or tripla vea shapes can he comhined togather with matching guides. Both pins and guides heva attached mounting pletes hy which they can he holted, screwed, or welded to the halvas, making up e complata flask sat.

basic pig iron A speciel high phosphorous, low sulphur, low silicon pig iron mada for opan haarth stael making.

bath Refers to tha molten metal on the hearth of a furnece during the melting procass.

battens Wooden bars or strips attachad to pattarns for rigidity and to pravant distortion during ramming of the mold (Fig. B-8). Thin flet petterns are often stiffaned with hettens for strength aftar tha

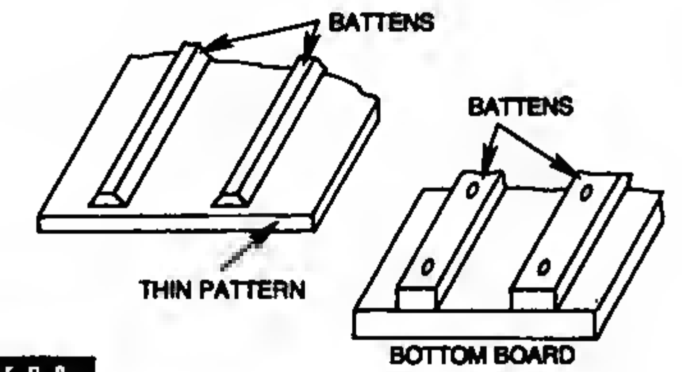

FIGURE B.8

Battens.

mold is made. The recess left in the mold by tha battans is stopped off with a core or molding sand and slaeked smooth. *Stiffeners*, runner taars on bottom boards, follow boards, atc., are often called *battens.*

bauxite An ore of aluminum, moderately pure hydrated alumina $A1_2O_3$. $2H_2O$. Theoretically 74 percent alumina. Bauxite bas a vary bigh malting point (1820 C.) and can ba usad directly as a rafractory material.

bay The longitudinal division of a foundry floor (Fig. B-9). Tbe araa betwaan tha bays is called tha *gongway* or *gongwoys.* Tba various sizas of castings produced are usually divided into bays.

bayberry wax A wax made from baybarrias—an old-timer in the foundry. It is used as a liquid pattarn parting by dissolving it in wbite gasoline. Tba pattern is coated and wben tha gasoline avaporates, a bard thin coating of bayberry wax is laft on tha pattern. It is also usad to coat cast iron castings to prevant rusting and as a molder's sbovel coating to prevent sand from adhering to the sbovel.

beam and sling Tba tackla arrangament used with a crane for turning over a copa or drag of a mold prior to assambly (Fig. B-10). Large flasks are fitted with *roll-over trunnions* over wbicb the bails are placed to roll-over tha flask saction. Tbe beam bas notches to adjust the distanca batwaan bails for tha various lengths of flasks.

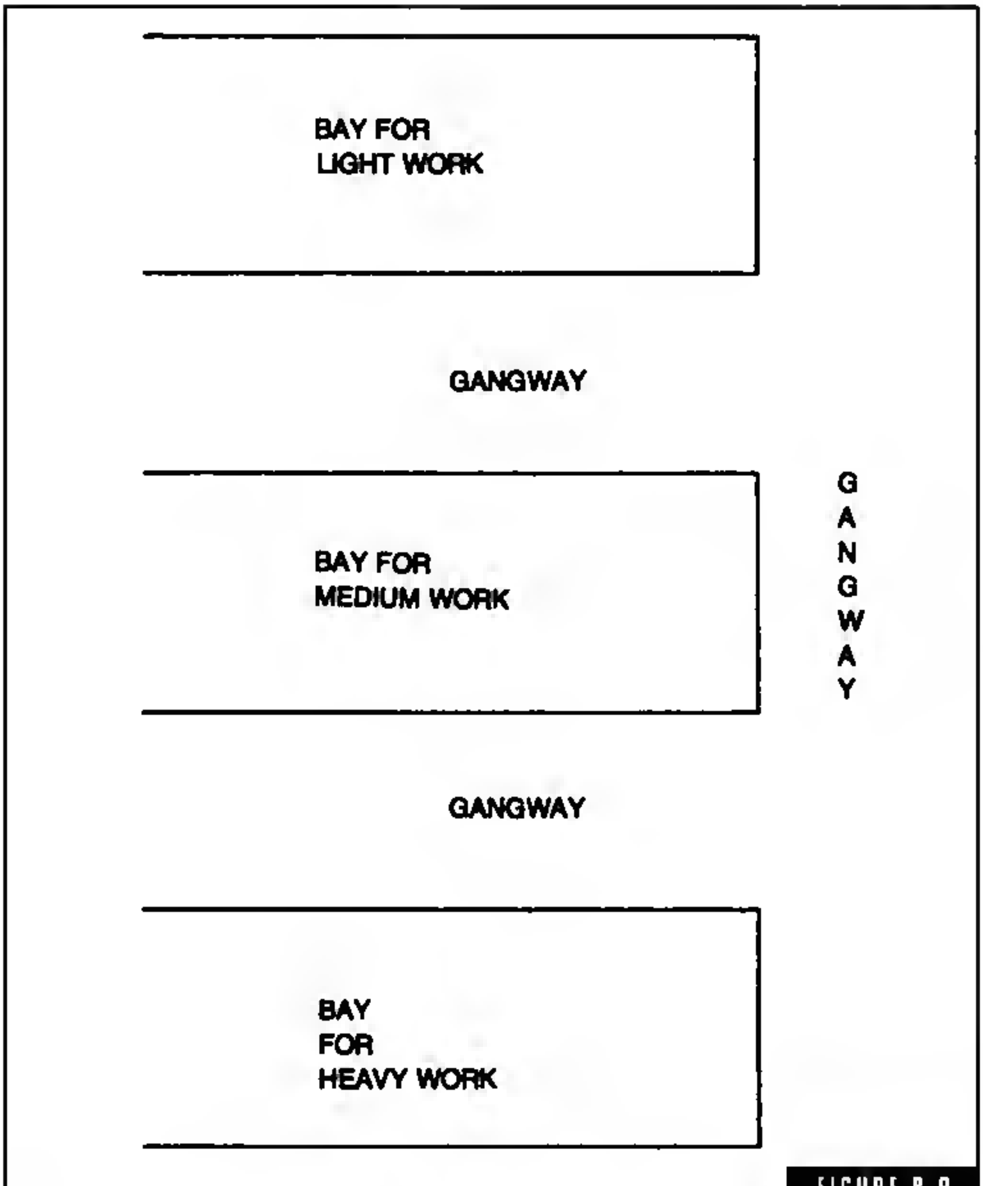

FIGURE B.9

Bays.

The beam should be constructed so that the slings cannot be jarred off the beam when in use. A hook on the ends of the beam adds to the safety factor.

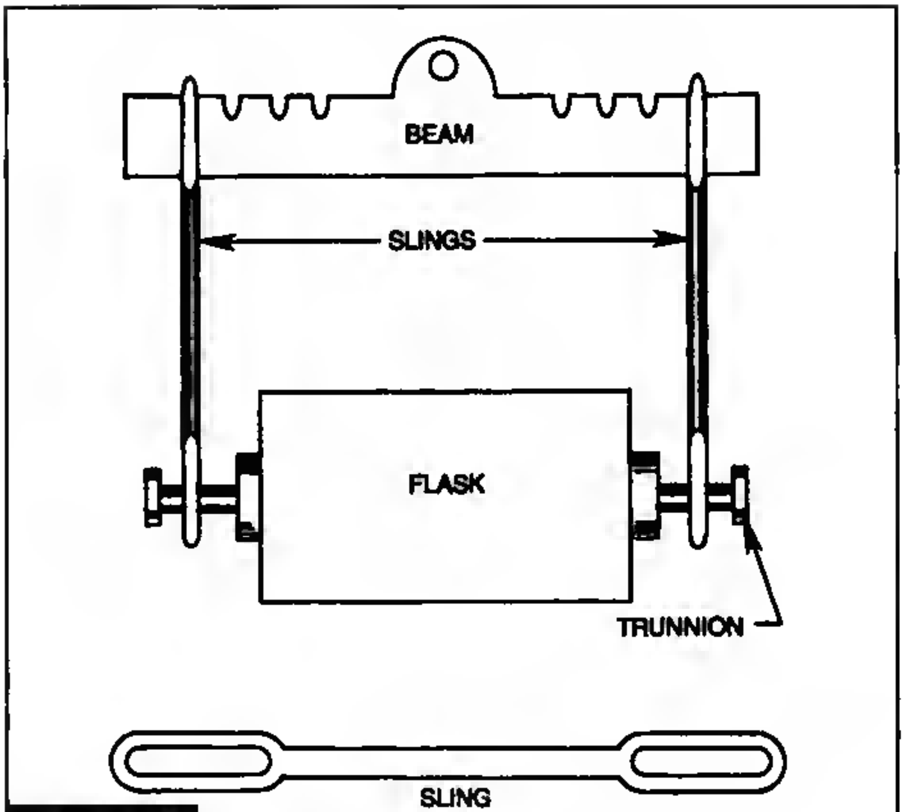

FIGURE B.10

Beam and sling arrangement.

bearing metals Any metels used es bearings, ferrous and nonferrous. There are bundreds of metals designeted es bearing metals—from bebbitts to oil-impregnated coppers.

bed Tbe initial cbarge of coke pleced in e cupole extending ebove the tuyeres on wbich the metal cbarges are melted. Tbe bed is replaced and mainteined at e fixed beight by the coke between metal cbarges (continuous melting).

bedding in With large patterns it is the prectice to place the drag side of the pettern in the pit or drag flask on a bed of lightly rammed sand (Fig. B-11). Ram and tuck the sand under the pettern and around the sides, working up to drag parting line. The pattern is usually lifted out prior to making up the cope so thet the drag mold can be checked for soft spots and also for the parting. When satisfied that the drag is right, the pettern is returned and the cope made up in the usual manne.. This system eliminates the

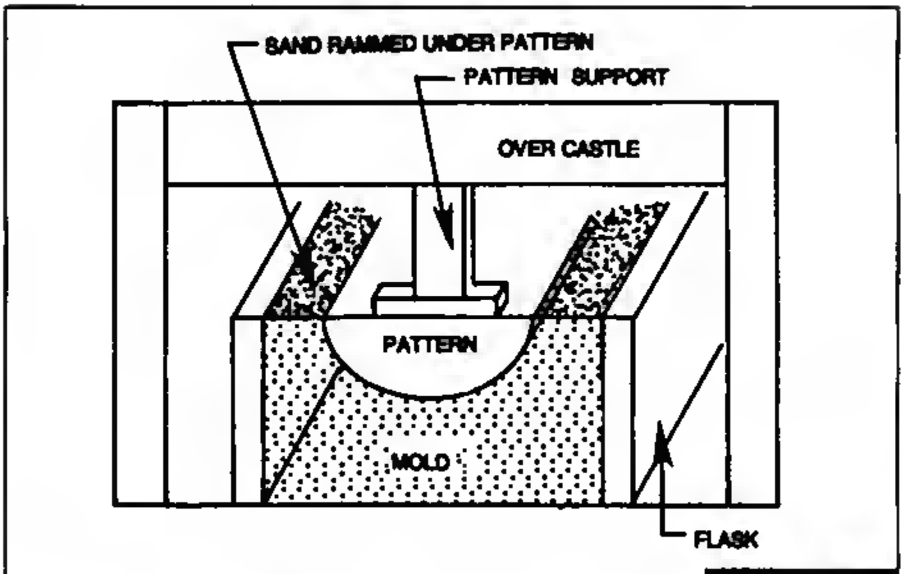

FIGURE B.11

The process of bedding-in.

necessity of rolling over the dreg—an advantoge with the production of large heavy castings. In some cases the pattern is supported during the bedding-in operation with an *overcostle.* The overcostle holds the pattern in the correct position during ramming and it is then removed to make up the cone.

beeswax Beeswax is used in wax fillet formulas and various investment waxes. It is e long chein ester, myried palmitete, and cerotic acid with a melting point of approximately 145 F.

bench lifter A simple steel tool with e right-angled square foot on one end of e flet bent blade (Fig. B-12).

This tool repeirs sand molds and lifts out any tramp or loose sand thet might have fallen into e pocket. To remove dirt from e

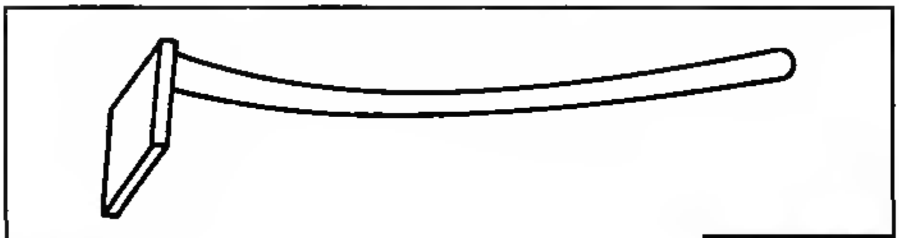

FIGURE B.12

Bench lifter.

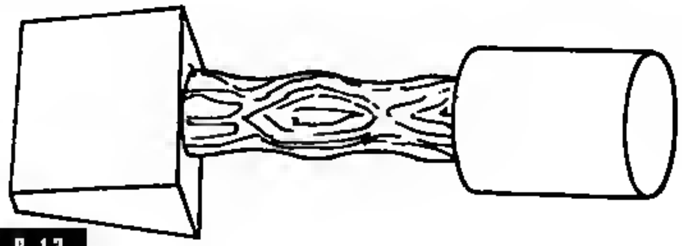

FIGURE B.13

Bench rammer.

pocket that will not blow out with the bellows, you simply spit on the heel of the lifter, reacb down, and pick it up, then wipe off the beel and go back and slick the spot down a bit.

bench molder A molder who produces small molds made on a molder's bench.

bench molds Small hand-rammed molds made on the molder's bench that can be bandled by one man. When they get too large, they are made on the floor and called *floor molds.*

bench rammer Made of oiled maple. You can buy one or turn one on a lathe and bandsaw the peen end into a wedge shape (Fig. B-13). The butt end is used to ram the sand tightly around the inside perimeter of the flask to prevent the cope or drag mold from falling out when either balf is moved, rolled over, or lifted.

bentonite A bydrous silicate of alumina, a colloidal clay derived from volcanic ash. It is employed as a binder in foundry sands and is added to naturally bonded sands to increase their green and dry strength. It is also used as an oil well mud and has numerous other commercial uses. A typical green sand formula uses bentonite as the principal binder. By composition it is 14 parts silica or beap sand, 6 parts bank sand, 1 part air float sea coal, and 1 part bentonite.

Bentonite is an unusual type of clay in that it swells 15 to 20 times its volume in water.

Two basic types are sold for foundry use—southern and western. The basic cbemical difference between the two is that the western bentonite is bigher in soda, alumina, and cbemical water (combined H_2O) and lower in potasb, lime, magnesia, and iron. Southern bentonite has less baked and bot strength. It collapses more readily, making it more suitable as a binder for light alu-

minum and bronze castings, where desirable. With steel and beavy castings, westarn bentonite will give tha added bot strength and retard premature collapsibility where needed.

It is e common practice to use the two blended together to produce the desired results for a particular type and weight of castings. Tbe most common blend appears to be 50/50.

beryllium bronze An alloy of copper and beryllium usuelly not more than 3 percent beryllium. Also called *beryllium copper*, it is used to produce strong mechanical parts, locomotive bearings, plastic molds, non-sparking tools, springs, etc. Beryllium bronze is defined es an alloy containing over 2 percent of beryllium or beryllium plus other metals othar than copper (over 2 percent).

No flux is necessary in melting beryllium bronze. Beryllium itself is e good deoxidizer. Some melters use e dry cbarcoal cover when melting. The pouring range varies somewbet with the percent baryllium in the alloy being cast (Tabla B-1).

Beryllium bronze should be bandled like aluminum bronze because it bas a tendency to dross.

TABLE B.1 Beryllium Pouring Range.

Per Cent Beryllium	Pouring Range
1.90 to 2.15	1900/2100°F.
2.50 to 2.75	1850/1900°F
.45 to .60	2050/2200°F.

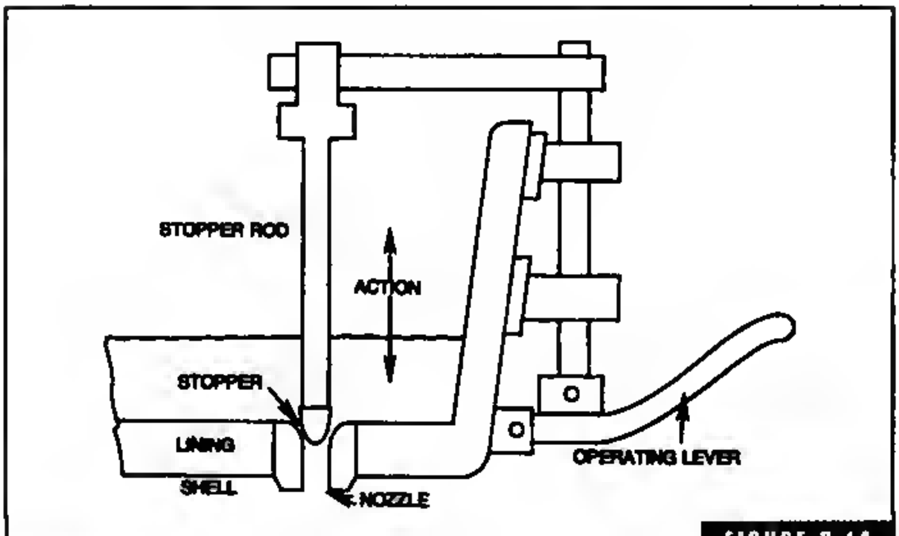

FIGURE B.14

Bessemer ladle.

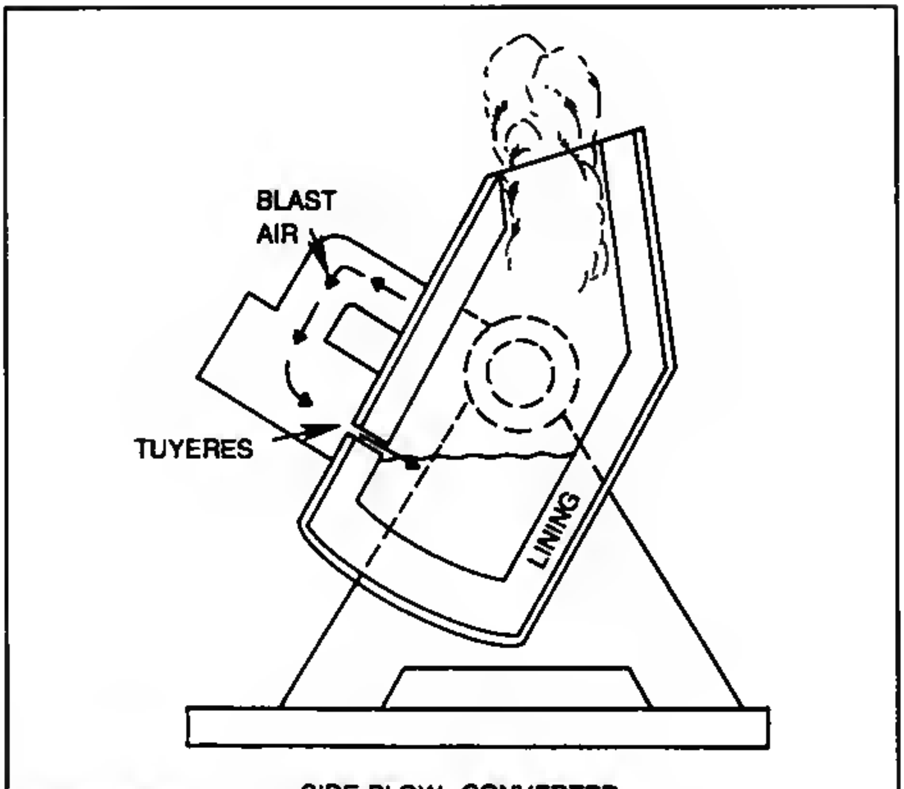

FIGURE B.15

Bessemer process.

bessemer ladle A steel ladle lined with refractory material and having one or more stopper and nozzle systems for bottom pouring (Fig. B-14). The stopper is attached to the end of the stopper rod, which is insulated with refractory sleeves. The stopper plug is seated in the nozzle when closed. The nozzle is opened to pour or teem by raising the stopper rod by a lever attached to the outside of the ladle and the top of the stopper rod.

bessemer process A steel-making process that blows air through or over the molten pig iron in a converter, oxidizing the silicon and carbon (Fig. B-15). The carbon is reduced to carbon monoxide and liberated as gas and the oxides of maganese and silicon form with the slag. The reactions which take place are exothermic and no additional heat is necessary in the refining process, which is called the *blow*. It takes approximately 20 minutes to blow a heat. When the heat is finished it consists of some iron oxide, .03 percent silicon and manganese and approximately .06

percent carbon. Tbe desired carhon content is adjusted by edding the proper amount of cupole iron and edjusting the composition with ferro alloys. Tbe converter is mounted on trunnions so that it can he tipped for charging, hlowing, and pouring. The air is fed to the tuyeres througb one of the bollow trunnions. In the side-blow converter the air is blown ecross the top fece of the charge and the angle is adjusted hy the operator. In the bottom blow converter the air is hlown in through the cbarge from the bottom.

binder Any meterial used to hold e mold or core meterial together in tha graen or dry state sucb es cerael, pitch, resin, oil, sulphete, water gless, latex, etc. In an oil sand core, the oil is the binder. When baked, it cements or glues the sand grains together.

blacking or mold wash scab A case wbera the blecking or wesh on the mold or core, when heeted, breaks ewey and lifts off the surfece like e leaf and is retained in or on the matal. Tbe ceuse is e poor binder in the wesh, an improperly dried wesh, e poor wesb formule, or all of these possihilities.

blackstrap foundry molasses A haavy, nonedible molesses wbicb bes heen traated chemically to pravent it from souring or farmenting. It is used as a hinder in core and mold washes, spreys, pestes, dough rolls, and core dauhing. Also used in skin-dried work hy tempering the fecing sand with e mixture of 1 part molesses to 10 parts water. It is a good spray et 10 to 1 for green sand cores which hava heen dried et 350 to 400 F. Spreyed wbile bot, it gives the core e nice firm skin.

blacking scab A casting defect. It is ceused by mold blecking or wesb flaking off the mold surface due to sand expansion and being retained in or on the surface of the casting. The ceuse is usually due to an excessively strong bond in the wash or not enough cushion meterial in the sand or wasb. It is also releted to *backing holes*, wbicb are irregular-shaped surface cavities containing carbonaceous metter.

blast Tbe wind or air supplied to a cupola, converter, or furnece to support combustion.

blast cleaning Cleaning (removing sand or oxide scale) hy impinging action of sand, grit, or sbot projected by eir, water, or centrifugel force.

blast gate A sliding metal gate used to·edjust the flow of air to the cupole wind belt, and the air to burners on some types of nonfer-

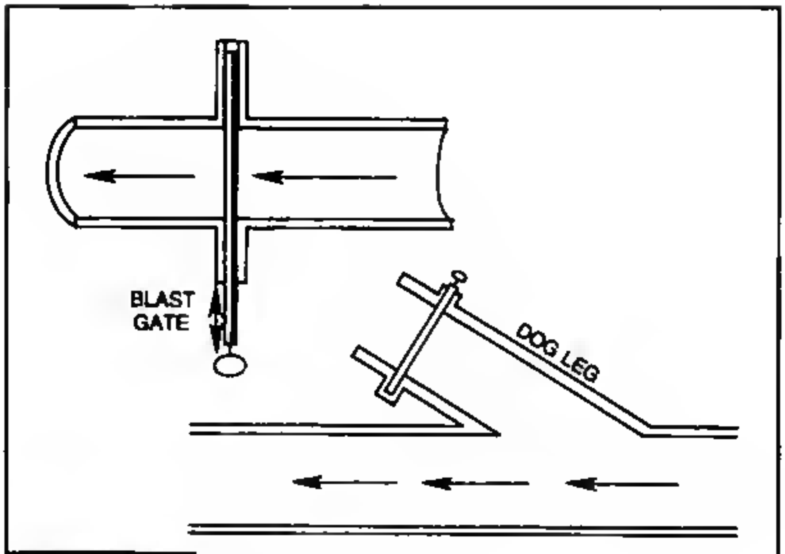

FIGURE B.16

Blast gate.

rous furnaces (Fig. B-16). There are two schools of thought as to where it should go. The first school says in the blast pipe proper and the second school says in a dog leg from the blast pipe to spill the air from the blower. Thus when closed, the air flows fully through the blast pipe and when open, less flows through the blast pipe. With the second arrangement the blower operates at a constant speed and load. With the first, when it is closed or partially closed there is a back pressure on the blower.

bleeder A defect caused by shaking the casting out too soon when a portion of it is still liquid. The section runs out, leaving a defect. In extreme cases the entire center section will run out onto the shake-out man's feet.

blended sands Use the suggested sand blends in Table B-2 as a guide in selecting your own basic blends. Start with a good high grade silica, washed, dried, screened, and graded. Adjustments can be made to the base after sufficient tracking is done.

blind riser A blind riser is any feed riser which does not extend through the cope to the atmosphere.

blind risers (foam) Blind risers are formed in a sand mold by using preformed styrofoam spheres and pear shapes which are stuck

TABLE B.2 Suggested Blended Sands.

Substance	Fineness	Permeability
Heavy iron using green or dry sand	61 & 50	80 to 120
Medium iron using green sand	70 & 45	50 to 70
Light squeezer iron, green sand	110 & 80	20 to 30
Stove plate iron, green sand	200 & 160	9 to 17
Heavy green steel, green sand	60 & 35	140 to 290
Heavy steel, dry sand	55 & 40	90 to 250
Light squeezer malleable iron	130 & 95	20 to 40
Heavy malleable iron	80 & 70	40 to 70
Copper and monel	150 & 120	30 to 60
Aluminum	250 & 150	6 to 15
General brass	150 & 120	12 to 20

down on e loceting pin on the pattern et the riser site (Fig. B-17). The spheres and pears heve e preformed recess which fits down on the locet-ing pin. In operetion, the desired size of the sphere or pear is pleced on the locetor pin and the mold is rammed in the usual manner. When the cope is drewn, the styrofoam blind riser remains in the sand body. The metal poured into the mold veporizes the styrofoam, forming the riser to feed the casting. It is e common prectice to vent the riser form with e ¼ to 3/16 vent wire through the cope. The pin on the pettern should be taller than the depth of the retaining hole in the sty-rofoam riser form so thet the styro-foam shepe winds up ebove the pettern slightly. The pin length will vary depending upon whether the mold is hand rammed or rammed on e squeezer and how close the styrofoam form is to the top of the cope.

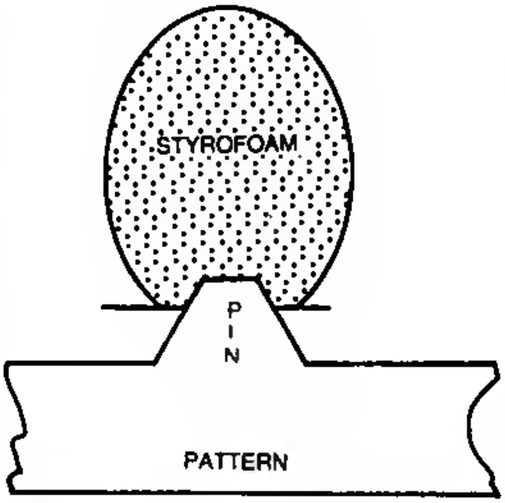

FIGURE B.17

Foam blind riser.

Spheres can be purchased in diameters from 2½ inches to 6 inches, or in pear shepes from 2½ inches to 6 inches. They may

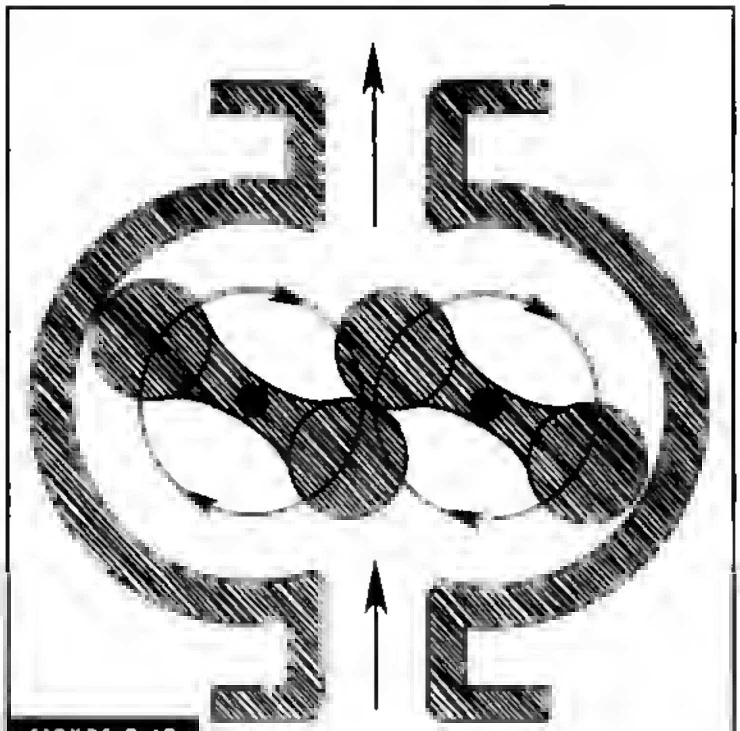

FIGURE B.18

A positive pressure blower.

be purchased from Frostee Foam Co., Box L, Antioch, IL 60002. Or, you can fabricete your own.

blister A shallow blow covered over with a thin film of metel.

bloating Tbe swelling of any refractory meteriel due to excessive heet or carbon monoxida in the furnaca.

blowers Blowers coma in all sizes and shepes (Figs. B-18 and B-19). They are reted in cubic feet per minute et various delivery pressures. The most common type of blower is the *centrifugol fon type*—a cast or fabricated case which turns a paddle type of impellor. The design of these blowers varies considerebly from manufacturer to manufecturer and also with the intended use for e particular blower. Blowers are often called *fons* in the foundry. In some blowers the impellor itself is *shrouded* on both sides with the idee that this increases its efficiency, both in pressure and volume. This question is up for grebs.

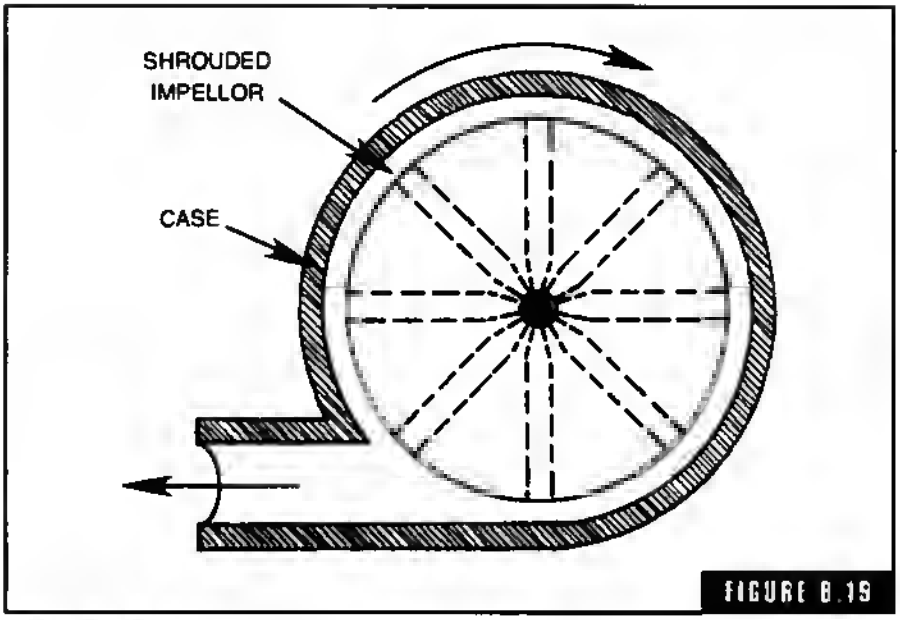

FIGURE B.19

Centrifugal blower.

Tha shrouds are rivatad or screwad to the edges of the bledes. Some blowers are compound. One stege delivers air to another stege, upping the output.

The other common type of foundry hlowar is tha *positive pressure blower*. Tbis type of hlower hes two lohe-sheped impellors wbich are geared to eech other to meintain an exect reletion between them et all times. Thay do not touch each other or the case, but are fitted so closely thet it is impossihla for the air, onca taken in, to pass beck through tha intaka.

Tbe positive pressure blower is superior to the centrifugel fan typa for supplying air to a cupola because the pressure remains constant regardless of conditions in the cupole.

blowing of cores Cores are often produced on machines called *core blowers*, which vary greatly in size, cepacity, and mecbanization (Fig. B-20). However, regardless of the blower design and size, the principal is the same. Tbe sand mix is blown into the core box by introducing air at high pressure on the sand in e reservoir, thus hlowing the sand into the core box through blow holes in the top of the core box and through the blow plate on the sand

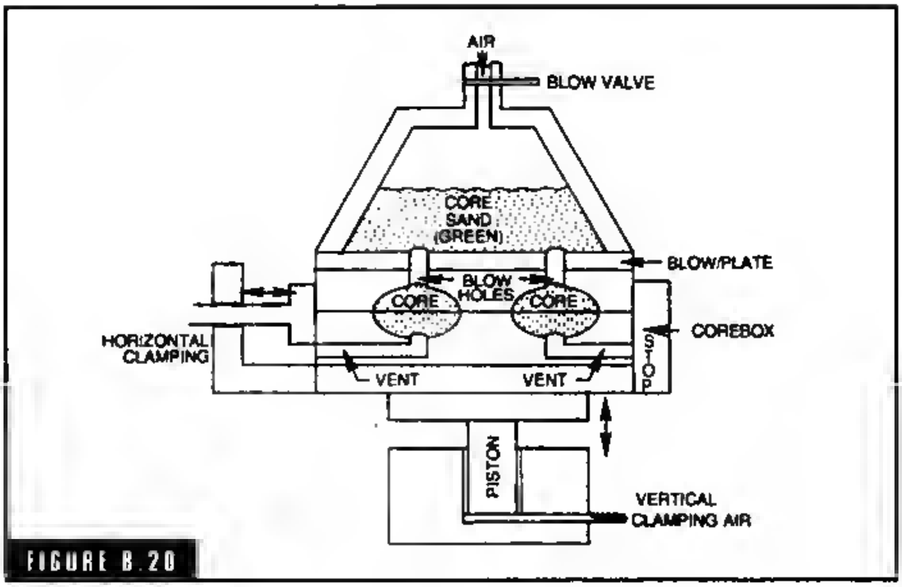

FIGURE B.20

Blowing of cores.

reservoir. The sand traveling at a high velocity is abruptly stopped by the cavity walls of the box, thus ramming itself. The air continues through the sand and out the vents in the core box.

The machine is provided with the mechanical arrangements for moving the reservoir to fill it and clamping the box vertically and horizontally as needed during the blow cycle. The controls are tied together in such a way that the blow cannot be made until the box is in position and properly clamped. The reservoir is exhausted prior to releasing the box.

blows Round to elongated holes caused by the generation or accumulation of entrapped gas or air. The usual cause of blow holes is:

- sand rammed too hard (decreasing the permeability)
- permeability too low for the job
- sand and core too wet (excessive moisture)
- insufficient or closed-off core vent
- green core not properly dried
- incompletely dried core or mold wash

- insufficient mold venting
- insufficient bydrostatic pressure (cope too sbort)
- copa bars too close to mold cavity
- wat gagger or soldier too closa to mold cavity
- poor grain distribution

Any combination of bot and cold materials leads to condansation as a bot cora is set in a mold or vice versa. A cold chill or bot chill will causa blows, as well as wet or rusty cbaplets.

blowy metal When a metal is gassed in melting to the point that it kicks and cburns in the furnace or ladle, it is referred to as blowy metal and sbould not be poured unless it can be saved by degassing or deoxidizing. With most metals simply re-melting again undar tha correct conditions will correct the problem. Metal pourad into a wet or incompletely driad ladla will kick and blow. Trying to dry a ladle with hot metal just won't work.

bobble Tbe casting will resembla a cold sbut or look lika it was poured sbort. The problam was a slackad or interrupted pour. When pouring a casting, the metal must be poured at a constant cboked valocity. If you slack off or reduca tha valocity, you can cause this defect. If you interrupt the pour, start—stop—and start, only for a second you may causa a bobble. A great percantaga of lost castings is caused by pouring improperly.

bolted cement A super fine *Portlond cement* used for *print bock* or *return facing*. In green sand casting wbera an axceptionally fina surface detail is required, as in casting art work, plaques, and grave markers the practice is to draw the pattern, dust the mold cavity lightly with boltad camant, and immadiataly return tha pattern to tha cavity and tap down. Then you redraw the pattern. This process sets the cement smoothly in tha cavity. Tbe mold is closad and poured in tha usual manner. If done properly, you can produca soma very fina work.

bolted charcoal Finely ground cbarcoal usad in a *dust bag* as a sbake-on mold facing and in print back work. Sometimes it is combined with graphite. It can be used as a parting dust. *Granuloted charcool* is usad as a cover on the surface of molten metal, especially brass, to prevent metal oxidation from the products of combustion.

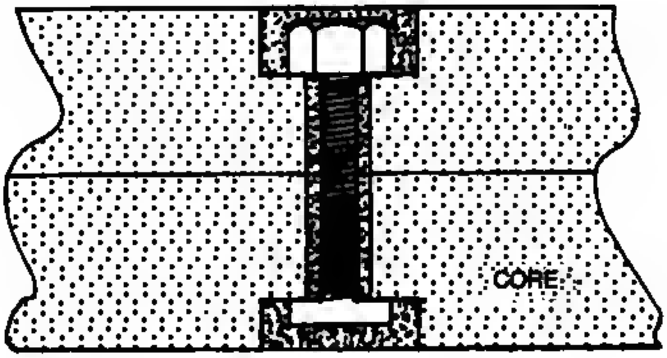

FIGURE B.21

Bolted cores.

bolted cores Tha practica of bolting cores together, wban it is falt that pasting could fail due to the pressure involved in pouring a particular (design) casting (Fig. B-21). Tba cores ara drilled and countersunk or provisions are mada in tha core box to form tha bolt boles. After bolting, the countersink recass must be fillad and muddad. Saparate cores can be made and baked and simply glued in place. The joint is then mudded.

bolting pads A pad or boss-type projection on a casting, which if not proparly dasignad or chilled, will produca a bot spot and localized shrinkaga at that point due to tha abrupt change of matal thickness (Fig. B-22). *Hot spots* are also causad by raisad pattern letters and incorrect rib design. If the bolting pads are large anough they can be cored out to prevent localized shrinkage.

bonding action of clay in molding sand Although most clay is sticky when moist, the sand grains of the mold are held in placa by clay wedges that hold the sand grains in place, as in a stone wall—the old wedga and block theory (Fig. B-23).

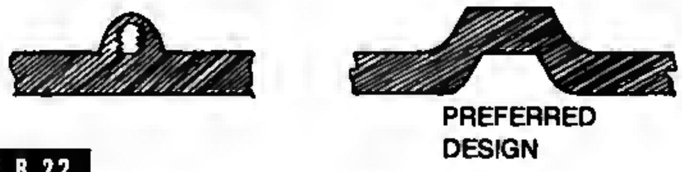

FIGURE B.22

Bolting pads.

bonding clays A large family of cleys used in bonding molding sands composed of ona or more of the minarals kaolinite, illite, and montomorillonite (Bentonite).

Cleys come about from the weathering of various types of volcanic ash. Clays are composed of minute crystelline flakes of constituent minerals. Generally the smaller the size of the particles of the cley minerals, the greater the bonding power.

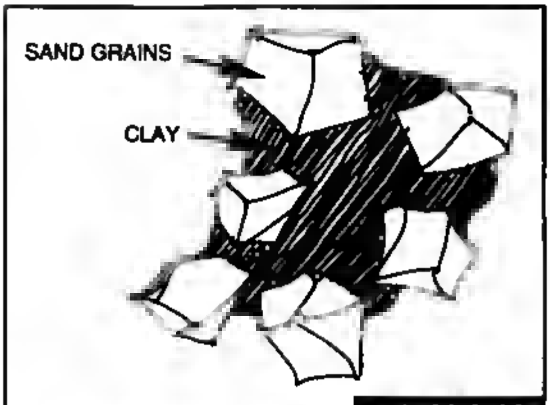

FIGURE B.23

The bonding action of clay in molding sand.

booking Booking refers to green and dry sand cores (Fig. B-24). Using e full-core box, ramming eech belf box with sand and striking both off leval with tha box and closing tham togather like e book brings the meting surfeces at tha parting line together. Than remove one helf box and place a *drier* in plece of the balf box thet wes removed. Roll the remeining balf box and drier over and remove the box leaving the core resting in the drier for baking. In the cese of e green sand core on e half arbor, remove the core from the box.

Flesks with *roll-off hinges*, wbere the cope is opened and closed like e book, are referred to as *booked molds*.

borax Hydrous sodium borete used in the foundry es e flux in melting metals.

boric acid Also celled boracic acid $B_2O_3 \cdot 3H_2O$, mede by edding hydrocbloric acid or sulphuric acid to borax and crystallizing. Its

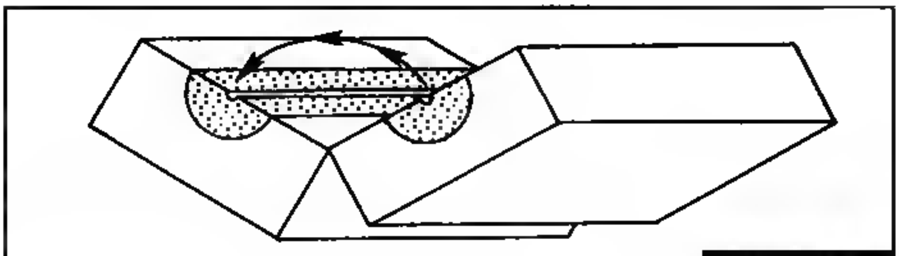

FIGURE B.24

Booking process.

main foundry use is as e protective agent in magnesium molding sands usually in combination with sulphur nr sulphur and flunride salts. It works to inhibit the ection of water vapor upon the hnt metal (Megnesium).

Use 3 to 6 percent by weigbt depending upon the section thickness of the cesting and the sand. Tbe more massive the casting, the greater the amount needed. Also the injection of e small amount of sulpbur dioxide gas into the mold just before pouring belps to prevent oxidetion of the surface of the casting.

bott A blunt cone of clay used to stop off the flow of iron from the tap bole of a cupole or air furnace. Tbere are many mixes formulated by the melter. One sucb mix is 5 parts molding sand, 5 parts clay, and 1 part wbeet flour.

Some tenders, after forming the bott and placing it on the *bott rod*, sprinkle e coeting of coal dust or grapbite on the bott with e sbake bag. This seems to belp release the bott when tepping, providing there is e parting between the tep bole and bott.

bott stick More often called e *bott rod*. It is e rod ¾ incb in diameter 8 feet long with e 2-inch diameter plete welded to the business end and e loop bandle on the other (Fig. B-25). It is used to plece the bott firmly into the tap bole of e cupola or air furnace to sbut off the flow of metal. Tbe bott is stuck to the flet plete by wetting the

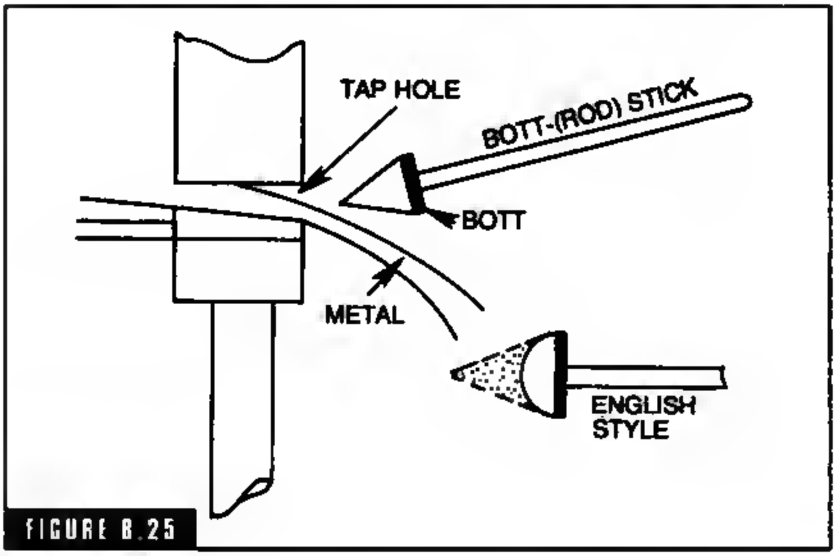

FIGURE B.25

A bolt rod.

plata and pressing it firmly into the tap bole, coming in at a sligbt angle above tha metal stream. When in placa, tha bar is twistad and slid downward to release the bott from tha rod.

Tba English bott rod is domed on the end. The theory is that a larga surface area will bold the bott and there will be less likelibood of losing the bott (of it falling off).

bottom board Tbe board usad to support tha sand mold until the mold is poured. It is constructed like the molding board, but need not be smooth—only level and stiff. Bottom boards from 10 × 16 incbas to 18 × 30 inches sbould ba mada of 1 inch thick lumber with two cleats mada of 2 × 3 incb stock. Bottom boards 48 × 30 incbes usa 1½-incb thick lumber with threa cleats made of 3 × 3 incb stock. Bottom boards 50 to 80 incbas use 2-incb thick lumber with four to fiva cleats mada of 3 × 4 incb stock.

bottom pouring Filling tha mold cavity from tha bottom by simpla displacament by means of gates antering the bottom of the mold from tha runner.

bottom sand Tba molding sand rammed against tha bottom doors of a cupola to form tha sloping baarth. Also called tha *crucible bottom*.

Soma brass meltars ram a molding sand bottom in a brass furnaca around the pedastal block. This makes it aasy to claan out the bottom for maintenance or to remova a spill in tha bottom.

bouyouzos A bydrometer calibrated in grams per litar. Tba hydromatar sbows tha numbar of grams still in suspansion at tha tima it is read. Used to datermine tha siza distribution of small particles.

brads Small, usually not beaded, wire nails usad in pattern and modal work. When beadad thay are then called *flotheod wire noils*. Brads run from ¼ incb long, 22 gauge to 3 incbas long, 12 gauge.

brasses Rad brass, leaded red brass, sami-rad brass, leaded semi-red brass, yellow brass, leadad yellow brass, bigh strength yellow brass, leaded high strangth brass, silicon brass, tin brass, tin nickel brass, nickel brass (nickal silvar), and leaded nickel brass.

brazing When you join metals by fusion of a nonferrous alloy that bas a malting point abova 800 F. but at a lower fusion point than tha metals being joined.

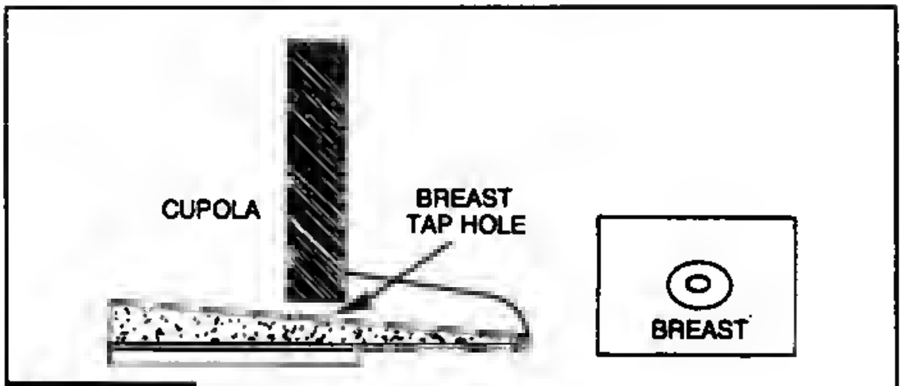

FIGURE B.26

The breast of the refractory portion of a cupola or air furnace.

Tha thraa basic types of brazing mathods are *torch brazing, furnoce brazing*, and *dip* or *flux brazing*. Torch brazing is done with a torch and rod (as filler matal). For furnaca brazing and dip brazing, tha parts are assamblad and tha fillar matal appliad as wire, wasbars, clips, and bands. Or thay may ba intagrally bonded.

Silvar soldaring is actually silvar brazing. Whan you gat balow 800 F. melting point (with your filler matal), you are soft soldering.

breast Tha rafractory portion of a cupola or air furnaca in wbich tha *tap hole* is located (Fig. B-26). It is located in the front of the cupola and on aacb side of an air furnace usually equipped with a *pouring spout*, whicb extands outward from tha furnaca to direct the stream of metal from the furnace into tha recaiving ladla.

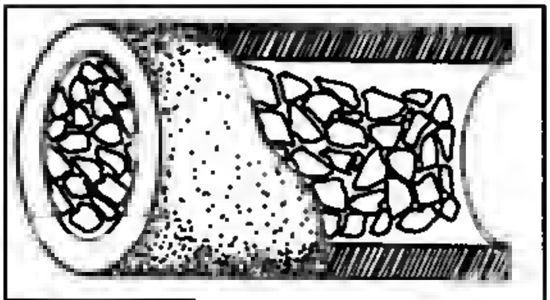

FIGURE B.27

A large core filled with breeze.

breeze Coke and coal screenings used to vent larga coras and molds (Fig. B-27). Widaly usad in larga sweap work and larga skelaton (pattern) work.

bridge chaplet Bridge chaplets are made of 20 gauge cold rolled steal and bot dip tinned or copper plated (Fig. B-28). An economical cbaplet for usa in castings where the conditions under whicb tha chaplets are used are not severe.

Brinnell hardness tester A device (press) wbich presses a 10mm diameter steel ball against e metal sample or casting at e known or given load—500 Kg for nonferrous, 3000 for ferrous. The diameter of the indention mede on the specimen in question is measured and the hardness number is taken from a table computing the bardness.

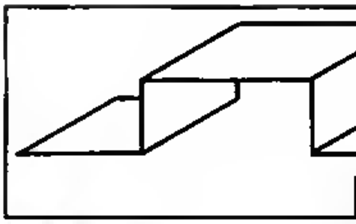

FIGURE B.28

Bridge chaplet.

briquets Compact or cylindrical-shaped blocks formed of finely divided materials. They are formed under pressure with various binders in order to increase their density and reduce their loss due to oxidation and draft in melting or treating e bath. Includes borings, chips, ferro alloys, silicon carbide, cbarcoal dust, coal dust, etc.

broken casting Often caused by improper design or improper filleting elong with improper handling anywbere elong the line. Copper base cestings, red brass, yellow bress, etc., are known as *hot short*—they break eesily wben hot. Tbus, if the cesting is shaken out of the mold before it hes cooled sufficiently, it can break very eesily. A mold or core wbicb bes e too bigh *hot strength* will not give or collapse to give the casting room to move as it shrinks. It will then hreak the casting.

bronzes Tin bronze, leeded tin bronze, high leeded tin bronze, leeded bronze, nickel bronze, leaded nickel bronze, aluminum bronze, silicon bronze, and beryllium bronze.

Brunelli strainer Invented by an Itelian foundry engineer (Fig. B-29). His claim is thet bis pouring system does eway with the necessity of risers or feeders on large castings. He also cleims the metal entering the mold is oxidized in proportion to the volume of air with wbich it comes in contact.

buckle An expansion scab, an indentetion on the fece of the cesting caused hy the sand being rammed too bard or not conteining sufficient combustible material sucb as wood flour or sea coal (Fig. B-30). The heet from the metel ceuses the sand to expand and it cannot do so without buckling. It is a very common defect in full-mold investment casting when insufficient gating is used and the mold fills too slowly, subjecting the mold walls to the beat for too long a period of time, causing excessive expansion and spalding.

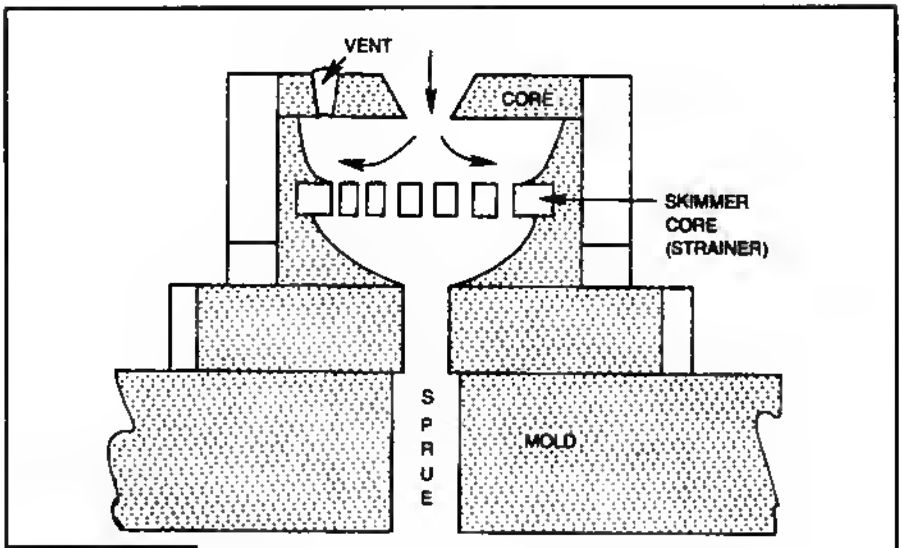

FIGURE B.29

Brunelli strainer.

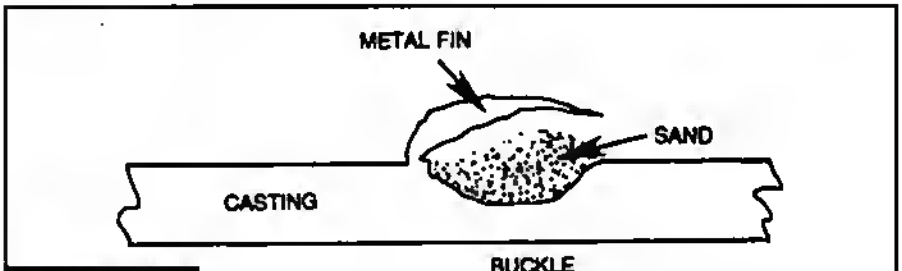

FIGURE B.30

A buckle.

bulb (paste) A sbort-snouted rubber bulb used to apply core paste to the joints of cores for pasting them together (Fig. B-31). Used to run a paste line on the drag of small molds to belp prevent a run-out at the joint and over the print on cores to stop metal from running over the ends and stopping off the core vent. Also used to put paste on the handle of the finisbing trowel in the back pocket of the molder. When he reaches for his trowel, be will get a good grip.

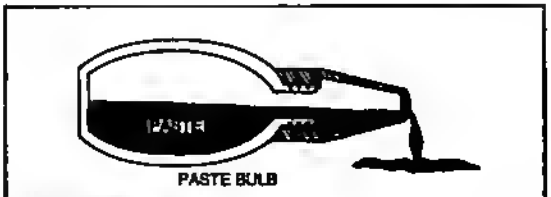

FIGURE B.31

A short-snouted rubber bulb.

bulb sponge Tbe bulb sponge consists of e rubber bulb with a bollow brass stem terminating in e soft brush (Fig. B-32). Tbe stem is pulled out and the bulb filled about three-fourths full of weter. The stem is then replaced. The bulb sponge is used to sweb around the pettern prior to drawing it, in the wey the flax sweb is used for floor molding. Tbe bulb is gently squeezed to keep the brusb wet while swabbing.

bull ladle A two-man ladle for carrying and pouring metal. It bas e sbank with two handles. When ledles get much over 200 pounds capacity, they become *crane* or *trolley ladles*.

bungs A section of e removeble arcb roof. In large air furnaces and kilns the roof is very often made by using cast iron frames that carry a section of the arched roof. The frames beve eyes for lifting them off with a crane for maintenance, cbarging, etc.

burned sand Molding sand in which the cley portion bes been destroyed by the beet of the metal.

button head chaplet Round-beaded cheplet with e forged or upset bead.

butt ramming Ramming the cope or drag with e butt-shepe rammer, either by band or pneumeticly. The butt rammer is the flat circular end of the rammer.

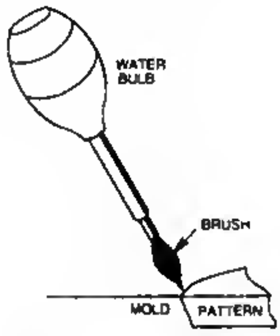

FIGURE B.32

Bulb sponge.

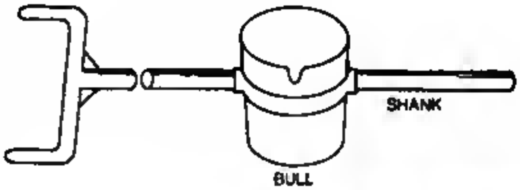

FIGURE B.33

Bull ladle.

FIGURE B.34

Butt raming is done with a butt-shaped rammer.

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cabbage head A puffed riser bead ceused by badly gassed metal (Fig. C-1). In copper casting the molder usually pours what is known es e *text cock*—a sprue cut into a box rammed with sand. If a cebbage head forms, tha matal is deoxidized egain and e second cock is poured. This process is repeated until the cock pulls (shrinks); then and only then is the mold poured. Very good insurance wben pouring a large mold. A good practice with any metal wbich is subjected to gassing.

calcium boride An alloy of celcium and boron CaB_8 used as a deoxidizer of nonferrous metals. Often the prime ingrediant in e commercial deoxidizer.

calcium carbide Produced by fusing lime and coke in the electric furnace. When calcium carbide is put into weter (or gets wet) it produces ecetylana gas and a residue of slaked lime. Widely used as a welding and cutting ges when combined with an oxygen oxy/ecetylene torch.

calcium manganese-silicon An alloy used as e scevenger for oxides, gasses, and nonmetellic impurities in steel.

calcium molybdate A crushad product of lime, molybdenum, iron, and silice used to edd molybdenum to iron and steel beets.

calcium silicon An elloy of calcium, silicon, and iron used es e deoxidizer and degessifiar for steel. Also known as *calcium silicide.*

calcium sulfate Tha principal binder used in full investment molds for cesting nonferrous metals. Gypsum, when calcined, is called *plaster of poris.* Typical formula for plester bonded investment is 2 parts plastar, 3 parts silicon flour, olivine flour or crushed red bricks.

camber As a defect, e warped casting. It is ceused by any number of problems: incorrect number and size of ribs; a design wbicb contributes to differentiel stress; flesk bars too close to the pattern; sand too strong in green, dry, or hot strength; or insufficient combustibles in the sand (wood flour etc.).

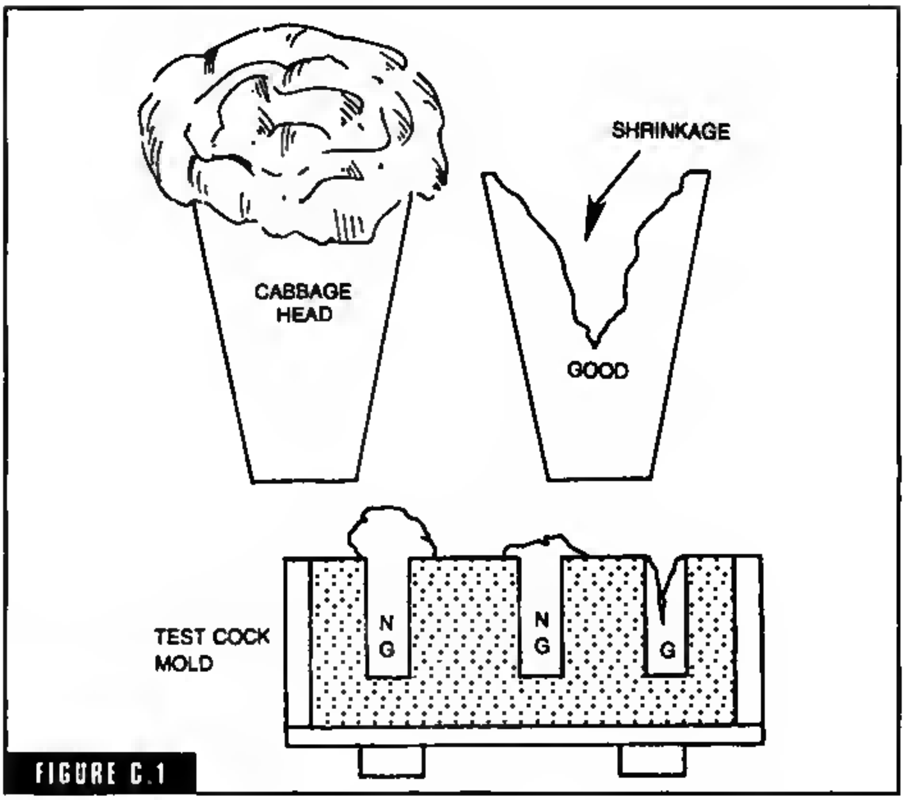


FIGURE C.1

Cabbage head.

camber (pattern) A pattern is intentionelly bowed, sprung, or faked to prevent e camber defect (warp) (Fig. C-2). The pettern is cambered in the opposite direction of the anticipated warp. If done correctly the casting will come out true.

In patterns for cest iron oil pans and sumps for trector engines, the pettern is often cambered in order to produce e straight flet surfece where the pan mates up with the engine.

compound camber A camber which is both hent and twisted.

captive foundry A foundry that is part of a manufacturing company or operetion which consumes its entire output and produces no castings for outside customers.

carbide A compound of carhon with one or more metallic elements such as silicon carbide, aluminum carbide, etc.

carbon dioxide A colorless, odorless gas, CO_2. Also called *carbonic anhydride* wben solid; dry ice. It is used to cure (set the binder) when making molds and cores using silicate of sode (water glass)

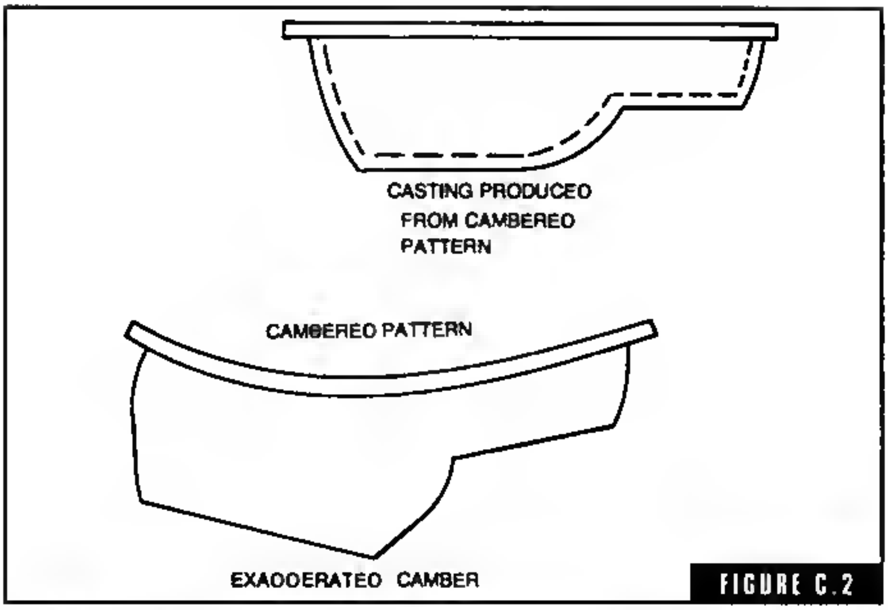


FIGURE C.2

Chamber patterns are internationally bowed or cambeed to prevent defects.

es the binder by passing the ges through the sand and silicate of soda mix.

carbon equivalent Tbe reletionship of the total carbon, silicon, and pbospborous content in e grey iron expressed by the formule:

$$\frac{\text{C.E.} = \text{T.C.} + \text{Si percent} + \text{P percent}}{3}$$

T.C. = Total carbon - Si = Silicon - P = Phosphorous

carbon (in gray iron) Carbon in grey iron is in two forms, combined (in solution) and free (graphite flakes). The ratio of combined to free carbon is controlled by the cbarge make up and silicon content. Silicon throws the combined carbon out into the iron in the form of free carbon. Strength properties are improved by the reduction of free carbon flakes and their uniform distribution. The smaller the flake size the better. The silicon lowers the solvent power of iron for carbon.

carbon steel Steel that owes its properties chiefly to its carbon content. It is without substantial amounts of other alloying elements. Also called *ordinary steel, straight carbon steel,* and *plain carbon steel.*

card pattern A number of small petterns fastened together by gates or to themselves (Fig. C-3). Bearing ceps and clutcb dog patterns are

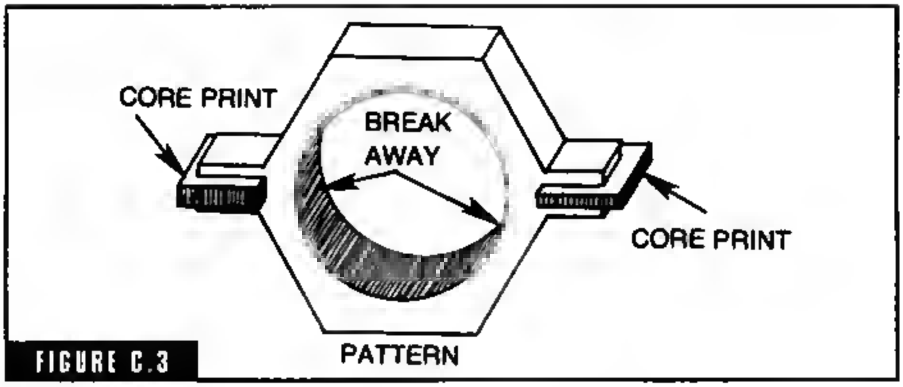


FIGURE C.3

Card pattern.

often carded and cast as e unit and sewed apart to produce the upper and lowar memher.

Bearing cap carded patterns beve the edvantaga that the bore is mechined before the cestings are parted. In this wey the radius of the upper and lower member is exactly the same es being machined et the same time on the same center.

card of patterns When several different loosaly gated patterns are assembled as e unit to ba molded in the sama flask.

car oven A large cora or mold drying oven with tracks on wbich e large car (containing the cores or molds) can be pusbad (rolled) into the oven for drying.

cast gate The gate through which the metal enters tha mold cavity. Also e gete cest to e metel pettern as part of the pettern.

cast steel Any object mede hy pouring molten steel into molds.

casting design An item to ba cast must be designed with the selected cesting method in mind. This requires e good working knowledge of casting methods and practices. If not, the foundry and pattern maker should be consulted; this will result in a great saving to the designer. It involves many, many factors such as metal selection, pattern equipment, casting method, finishing, etc. The cesting cost can often be greetly increesed hy overlooking some simple element.

casting ladle Any device used to transfer molten metal into a mold, as opposed to a *transfer ladle,* which is used to feed the casting ledles.

casting strains Internal strains resulting from the cooling of e cesting plus residual stresses. Strains in castings can be removed by var-

ious heet treating and stress relieving techniques. Tbe design, along with the particular metal poured, plays a great part in strains and stresses in e cesting.

cast structure The structure of e cast alloy consisting of cored dendrites and, in some alloys, a network of other constituents. The structure is on a microscopic scele. A micrograpb structurel study.

cast weldments The reduction of e complicated cesting into two or more simple castings, welded together to produce the desired part.

caustic dip A solution of sodium hydroxide (lye) and water used to clean the surface of a metal. Bright dip for aluminum castings. Also used as an etcb with aluminum alloys to reveal the microstructure.

cavitation erosion Erosion of a material due to the formation and collapsing of cevities in e liquid et the solid-liquid interfece. The principel of ultresonic cleaning in e liquid.

cement bonded sands Molds and cores produced by bonding silice sand with HI early cement and air drying for e minimum of 72 bours. Also known as *72 hour sand.* The first cement sand mix was patented by John Smith of Verone, Pennsylvania over 70 years ago. It consisted of 10 parts silica sand and 1 part portland cement moistened to 6 percent moisture with molasses water. It was used to cast both ferrous and nonferrous metals. Still used to some extent today, but largely replaced by furan no-bake mixes.

cementite The structure with the compound Fe_3C wbich forms when austenite changes on cooling. The combined carbon structure of cast iron is known as *austenite.*

center line A well defined geuge line pleced on the work or layout to serve es a basis from whicb dimensions are to be measured.

centrifugal casting The production of castings by centrifugal force (true centrifugal) where the molten metal is poured into a rotating mold at the axis of rotetion and is conveyed by centrifugal force out to the peripberal extremities leaving a bollow casting with the impurities in the center or bore (Fig. C-4). Cast iron and steel pipe are produced by this method, as are bronze bushing stocks.

centrifuging The process of casting wbereby the metal is driven into mold cavities which are loceted off the center of rotation (Fig. C-5). Tbese can be single or multiple cavities. The mold material

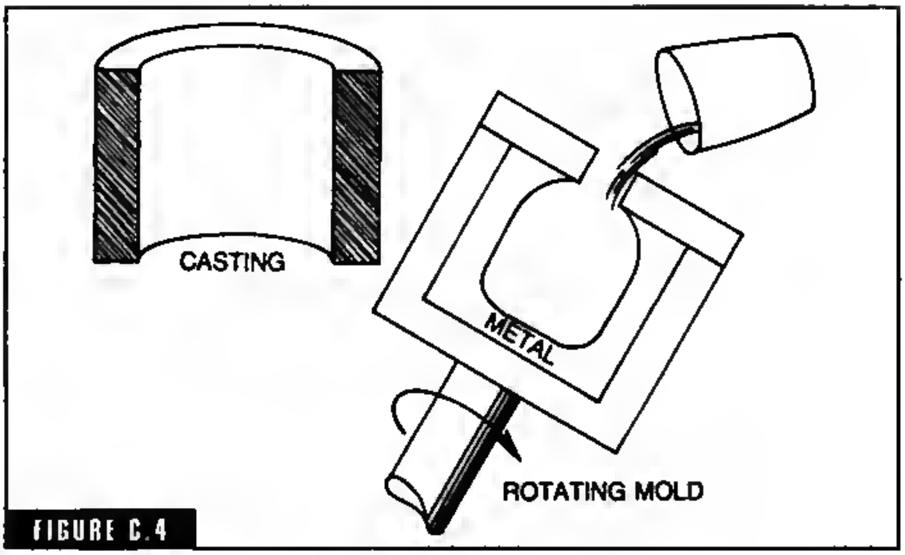


FIGURE C.4

Centrifugal casting.

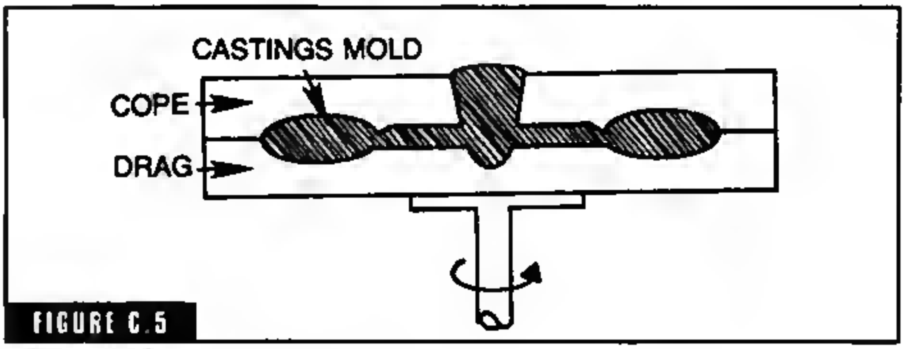


FIGURE C.5

Centrifuging.

can be metal, rubber, green sand, investment, carbon, etc. Often mistakenly called centrifugal casting.

center line shrinkage A defect wbicb can occur in any metal (Fig. C-6). It is most often found in steel in thin sections, elthough it is not relegated solely to thin sections. A shrinkage cevity in the center of the cesing wall due to the stopping of feed metal.

Tbis shrinkage can be elimineted by tepering the cesting to promote directional solidificetion toward the feed metal or padding. It can be removed by machining or grinding.

The author has seen cases of railroad trucks with centerline shrinkage to the point that they were hollow as if they were

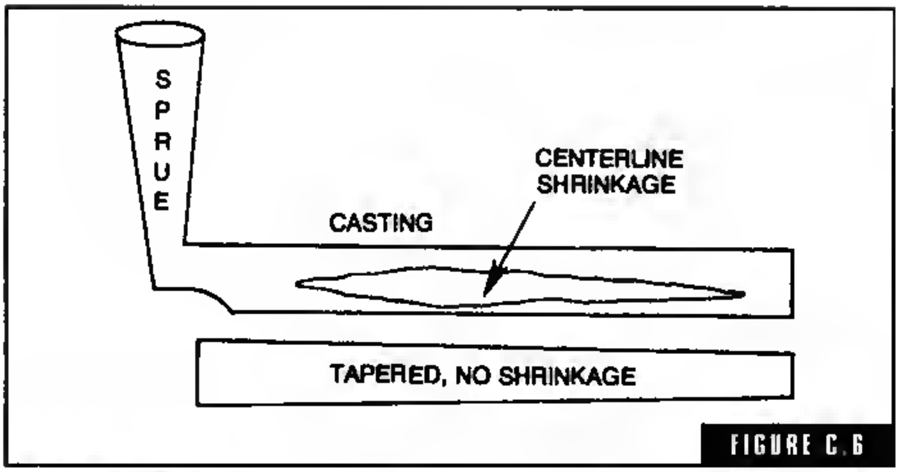


FIGURE C.6

Centerline shrinkage.

cored. They are not scrapped as it is e fect thet e casting with centerline shrinkage is serviceable if the load is flexual.

The euthor cast e very large pleque 6 × 4 feet, which was perfect in ell respects except for it is completely hollow centerline shrinkage.

Thet was some 25 or 26 years ago and it's still hanging on the building. The metal was 88 percent Cu, 10 percent Sn, and 2 percent Zn.

cereal A honding meterial and e cushion meterial. The most widely used in the foundry is corn flour produced from wet milling of corn starch. The effectiveness of corn flour depends entirely on how it is used. In synthetic sands it works well from ½ percent to 2½ percent hy weight. It is widely used in steel sands. The euthor uses corn flour in nonferrous sands to impart resilience. Corn flour increases dry compression strength, haked permeability, toughness, mulling time, moisture pick up, mold hardness and deformetion. It decreases the green permeability, sand expansion, hot compressive strength, and flowehility. Cereals are repleced with wood flour to some extent; however, each has its distinct use. Corn flour is very heneficial when you heve weak sands and no other edditive can eliminete or reduce scahs, rettails, buckles, and similar defects quite es well es 1 per cent to 1½ per cent corn flour edded to the facing. It also keeps spalling to e minimum.

chamfer To hevel e sharp edge (Fig. C-7).

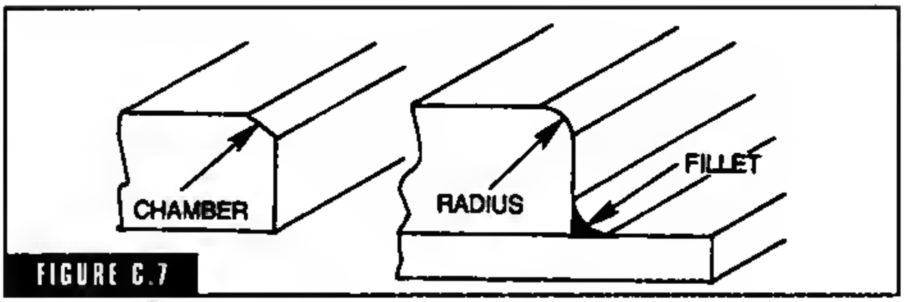


FIGURE C.7

Chamfer.

chamotte A refractory produced from bigb alumina clays that hava baan calcinad to a temperature above their softening point.

chaplet clips Clips used to attacb two or mora chaplets togather whan the proper siza is not availabla in your cbaplet stock (Fig. C-8).

chaplets A larga family of matal devices, supports, or spacars usad to support cores in molds long enough for the matal to solidify without moving or breaking a cora during pouring (Fig. C-9.) Thay burn in and become part of the parent metal. Chaplets are not used when the pattern bas sufficiant core prints, whicb sarve the same purposa.

charcoal A highly amorpbous carbon fuel produced by heating wood in tha absance of oxygen; used widely to melt in tha cupola at ona time and as a covar matarial on metal baths, in cora and mold washas, etc. At one time all iron was melted using charcoal as a fual.

charge Tha metal placed in a cupola or furnaca for melting.

cheek A section of flask betwean tha copa and tha drag sections of a flask to decrease the difficulty of molding an unusual shape or to fill tha need for mora than ona parting lina (Fig. C-10).

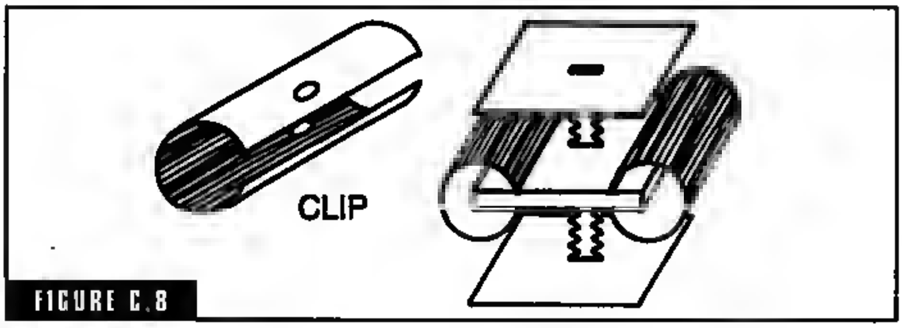


FIGURE C.8

Chaplet chips.

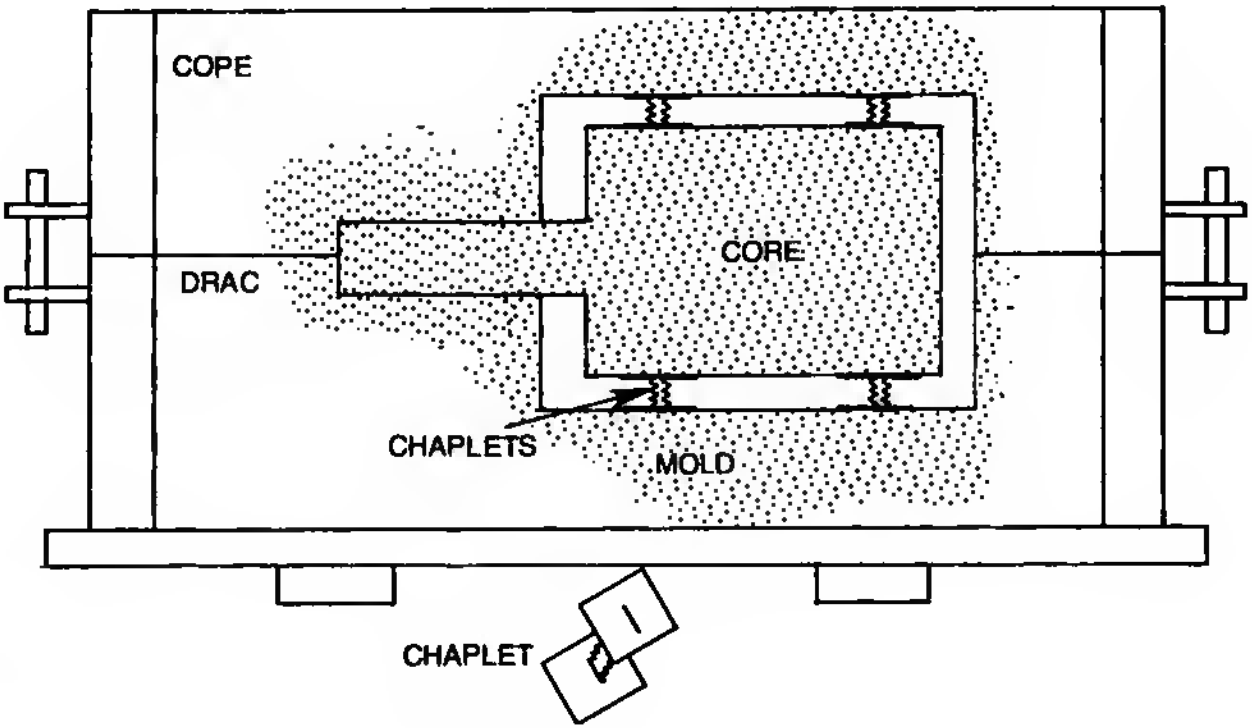


FIGURE C.9

Chaplets.

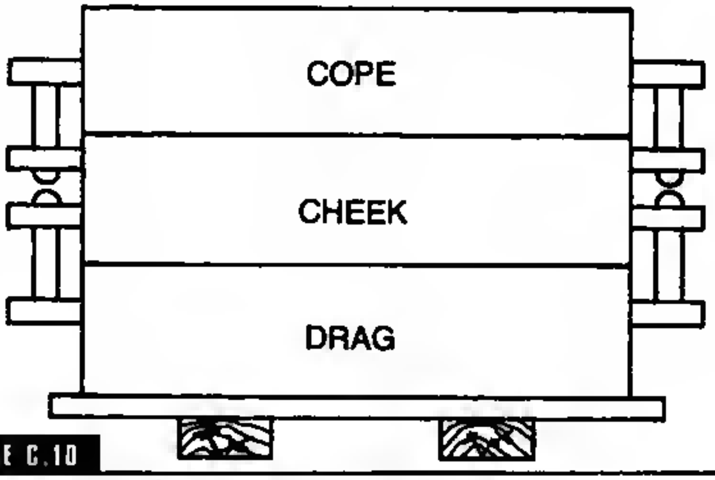


FIGURE C.10

Cheek is the section of flask between the cope and drag section.

chill Metallic inserts (usually cast iron) located in the mold to promote rapid cooling at a desired point to make the casting harder at this point or to promote directional solidification and prevent shrinkage at a hot spot which cannot he fed from a riser (Fig. C-11). They can he internal as well as external.

chilled edges A condition (defect) in thin cast iron where the edges of the casting are hard (white iron). (Fig. C-12). The major cause is that the carbon equivalent is too low for the section heing cast. If the CE is too high for the section it will *kish* (excessive free graphite at the edges and thin sections).

chill nails Large-headed nails used as internal and external chills (Fig. C-13). Horseshoe nails are widely used due to the head mass. The

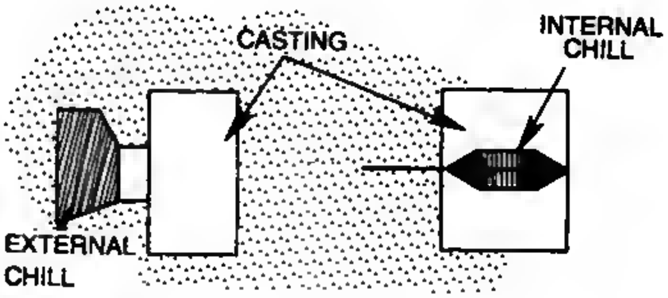


FIGURE C.11

Chills are metallic inserts.

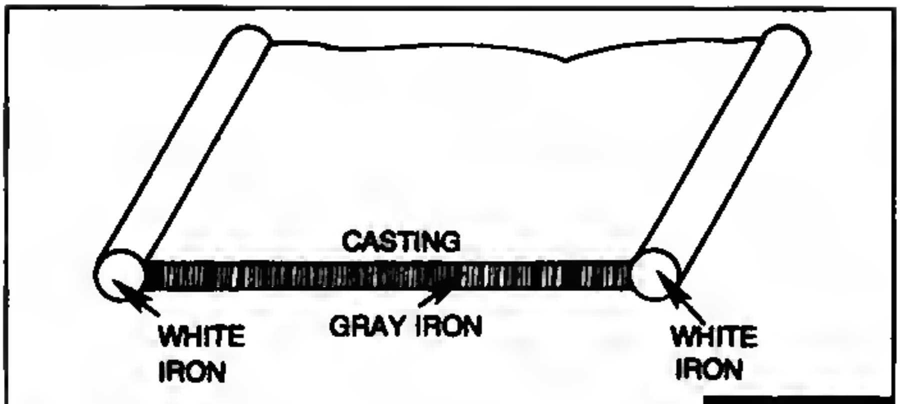


FIGURE C.12

Chilled edge.

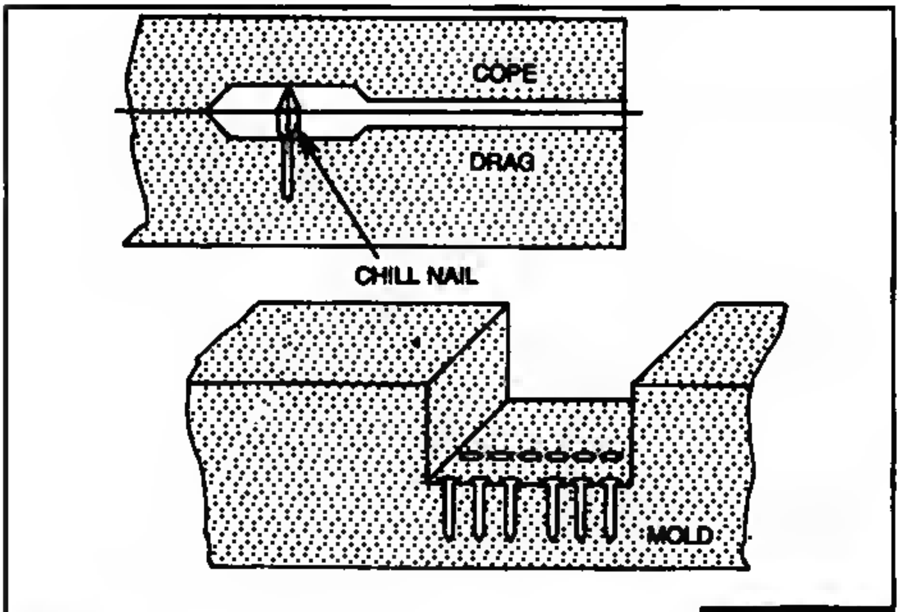


FIGURE C.13

Chill nails.

nails are pushed into the sand at the point to be chilled. *Fanner chips* are a specially manufactured nail for internal chilling.

chill wash A wash coating applied to external chills to prevent them from kicking and blowing, causing a defect at their point of contact with the casting. These wash coatings include washes of lube

oil and grapbite, lard oil, red lead and water (dry thoroughly), shellac, and alcohol and resin.

chloration The process of passing chlorine gas through molten magnesium to remove dissolved gasses and trapped oxides (a degassing and refining process).

choking Keeping the pouring basin brimming full from start to finish when pouring a casting.

Christmas tree A single sprue containing many castings formed by a stacked mold.

chrome pickle A pickling solution for dipping magnesium castings; it produces a protective film on the casting and provides a base for painting. It consists of a solution of nitric acid and sodium dichromate.

chromium An elementary metal, Cr, used as an alloy in stainless steels, heat resistant steels, and higb strength steels for plating, hard facing ferrous alloys, cast iron, etc.

churning Also called *feeding* or *pumping*. A molder churns the liquid metal in a riser with a wrought iron bar to keep it open and to assist in feeding the casting.

cinder mill A revolving tumbler used to wash, cool, and retrieve good coke and iron from the cupola drop. When the day's beat is over, the bottom doors on the cupola are dropped and the coke and iron remaining drop out. It is quenched with water and sent to the cinder mill.

clamp off A defect caused by the displacement of sand in a mold due to clamping or improper bandling of weights. It results in an indentation in the casting surface.

clay tile gates The use of pre-formed gate tiles of ceramic materials with large iron and steel castings to prevent the washing and eroding of the mold and its gating system during pouring. It is basically a plumbing system of ceramic piping, elbows, tees, and splasb tiles. These tiles can be purchased in a wide variety of sizes just like plumbing ware.

cleaning castings Removing the sand and oxide scale and shaking out the cores by hand, sand blasting, sbot blasting, chemical pickling, etc.

This often represents a good chunk of the cost of producing the casting.

cleavage plane The junction wbere two independent planes of crystal growth meet and interfere with each other (Fig. C-14). This con-

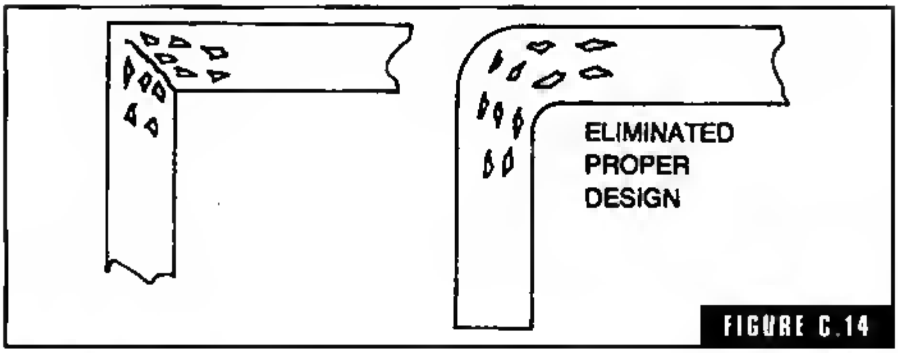


FIGURE C.14

Cleavage plane.

dition produces a weak point at the junction. Its primary cause is a sharp edge or junction which is not filleted.

cohesion The force by wbicb various particlas are hald togather. Factors ara bot or cold workings of the material and the molecular arrangement due to heat treatment or chamical action.

coke The residue or product left—mainly fixed carbon and ash—produced by heating-heating bituminous coal in the ahsence of air to 1200 to 1400 C and axpalling tha volatila matter.

A good grade coal will produce from 1 ton of coal, .7 tons of coka, 11,5000 cubic feet of gas, 12 gallons of tar, 27 pounds ammonium sulphata, 50 gallons of benzol, and .9 gallon of tolluol and naphtha.

Foundry coke should have an ignition point of 1000 F; sulpbur, maximum .7 percent; and be strong enough to carry the charges in the cupola. Coka is widely usad as the fuel in tha blast furnace.

cold chamber die casting In the cold cbamber machina tha metal is ladled into tha sbot cbamber, not submerged in the molten bath as the hot cbamber machines (Fig. C-15).

cold shortness Metals that are brittle at room or low temperatures are called cold sbort metals.

cold shot Where two streams of metal in a mold fail to weld together. This defect is usually caused by a metal too cold poured too slowly or a gating system improperly designed so that the mold cannot ba filled fast enough.

collapsibility A measurement of the ease or resistance of a sand mixture or core to breaking down under castings conditions.

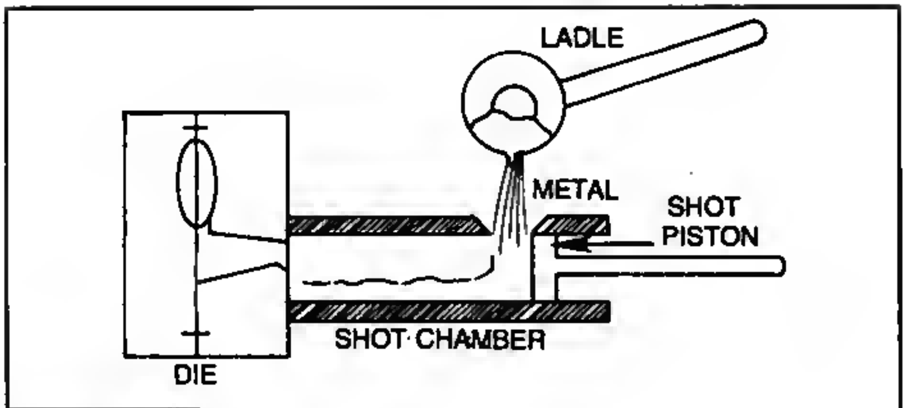


FIGURE C.15

Cold chamber die casting.

A core in e casting must collepse as the cesting cools and shrinks to prevent bot tearing and to fecilitate tha removal of tha core. Tbe degree of collapsibility, a factor of hot strength, varies depending on the pouring tempereture, casting design, metal, and the size of the casting.

The mold and core must collapsa at the right time. A core in an aluminum cesting must collapse at a fairly low temperatura and much fester than ona for a stael casting. It is controlled by the typa, kind, and amount of hinder used.

colloids Materials less than .0002 inchas in size, geletinous, bigbly absorbent, and sticky when wat.

combination core box A core box that may be altered with a plug or stop off to produce e core of another sbape. Such a hox is huilt so that a left- and right-hand core can be made from the same box.

combined carbon Carbon chemically combined in iron and steel.

combined water Water chamically combined in a mineral matter and can be driven off only by temperatures above the hoiling point of weter. The removal of combined water is called *calcining.*

combustibility Tbe ability of a substance to burn or combust. Combustion is the chemical change resulting from the comhination of combustible constituents of a matter with oxygen, producing heat energy.

compressive strength The maximum stress thet a material can stand without a predefined amount of deformation when subjected to compression.

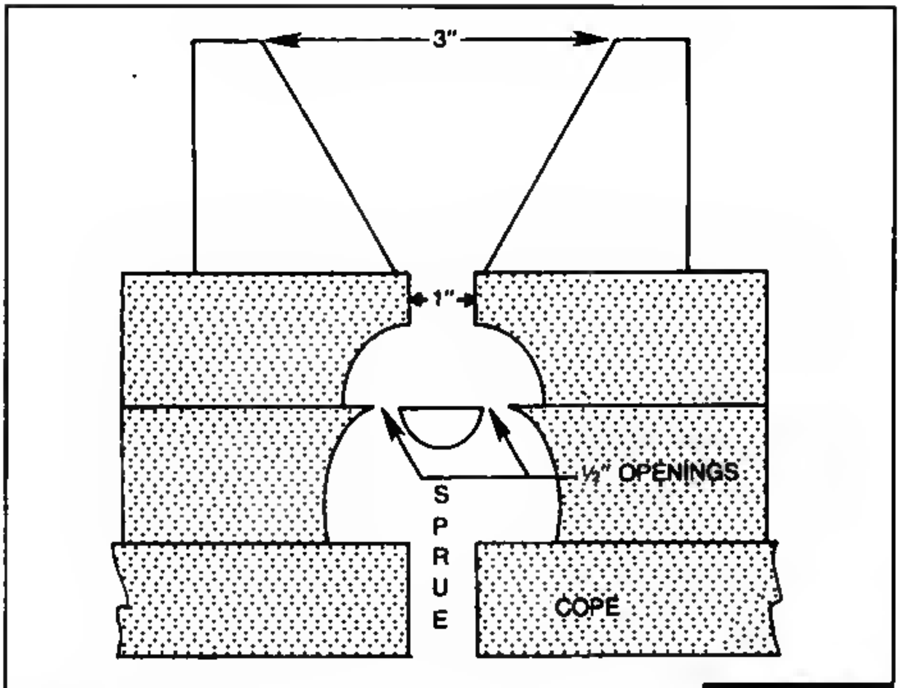


FIGURE C.16

Compound skimmer.

compound skimmer A skimmer and pouring head arrangement combined (Fig. C-16).

condensation Moisture formed from placing a hot core in a cold mold or a cold chill in a hot mold and causing a blow defect.

contraction The reduction in size of material as it cools from an elevated heat to room temperature. The contraction of most bronze alloys from molten to room temperature is $\frac{3}{16}$ of an inch per foot.

cope The upper or topmost section of a flask, mold, or pattern.

cope and drag mounts Two separate pattern mounts, one fitted with female guides for the drag and one fitted with pins for the cope. These must match up with the flask used (Fig. C-17).

The cope half of the pattern is attached to the cope mount and the drag pattern is attached to the drag mount. The cope and drag molds are produced separately and put together for pouring. The usual practice is for one molder to make copes and another to make the drags. Cope and drag mounts are quite common when

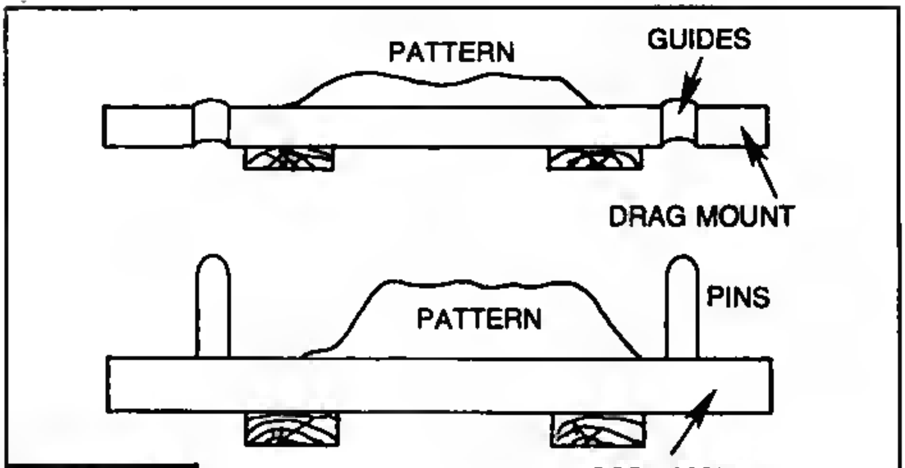


FIGURE C.17

Cope and drag mounts.

making larga castings where a matchplata would he out of the question due to its bulk and weight. Copa and drag mounts are somatimas callad *tubs.*

coping out Extanding tha sand of the copa downward into tha drag by cutting away a portion of the sand in tha drag. This is dona prior to ramming tha cope to facilitata mold making and removal of tha pattern hy establishing the correct mold parting. It also eliminatas hack draft (Fig. C-18).

copper Yellowish red in color, tough, ductile, and mallaabla metal. Found native in a larga number of ores. Melting point, 1083 C; hoiling point, 2310 C; specific gravity 8.91; and weight .321 pounds par cuhic inch.

Sound copper castings are difficult to produce dua to the affinity to oxygen when melting. Melt on the oxidizing side with a charcoal covar and daoxidize with phos-coppar 1½ to 2 ouncas per 100 pounds. In the south we naver meltad and poured copper on a rainy day or ona with high humidity. Larga risers ara raquired due to its high shrinkage. Dry sand molds, cement sand molds, and furan no-bake molds are your best bet for medium-to-heavy copper castings.

copper base alloy Any alloy where the main constituent is copper. Copper is alloyed with lead, zinc, nickel, tin, silicon, etc.

85 percent copper, 5 percent tin, 5 percent lead, and 5 percent zinc is called *ounce metal* or *red brass.*

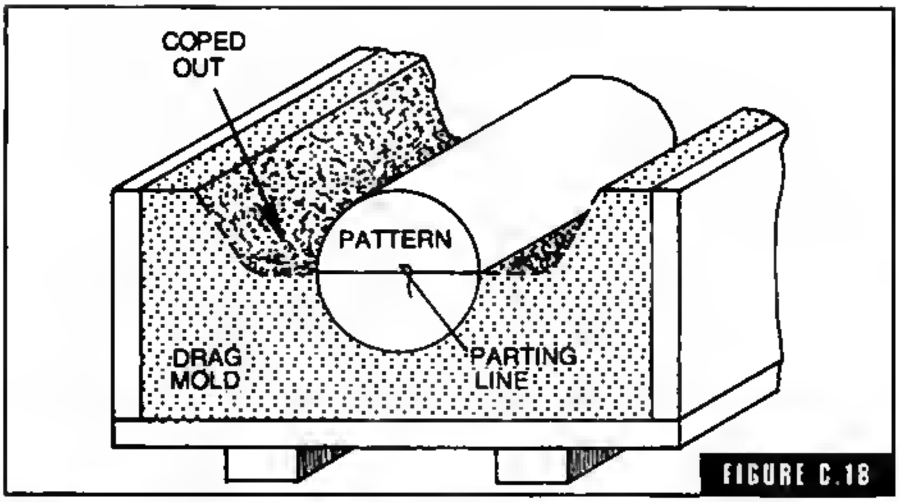


FIGURE C.18

Coping out cuts away a portion of the sand in the drag.

copper phosphorous Also known es *phos copper.* It is e metal deoxidizer mede of copper containing various percentages of phosphorous sold in shot and wafer form. The two most popular percentages are 10 and 15 percent. The phosphorous is comhined with the copper to make it stehle so it can he handled sefely. The usual amount used in e red hress heet is 1 to 2 ounces of 15 percent phos copper per 100 pounds of metal (15 percent phosphorous; 85 percent copper).

The copper melts, releasing the phosphorous which comhines with the copper oxides in the melt and releases the copper as oxide-free copper.

core A pre-formed baked sand or green sand aggregete inserted in a mold to shape the interior part of a casting which cannot he sheped hy the pettern (Fig. C-19).

When e pattern requires a core, a projection must he made on the pattern. This projection forms an impression in the sand of the mold in which to locete the core and hold it during the casting. These projections are celled *core prints* and are part of the pettern.

Sometimes it is possible to make a pattern in such a wey that a core will remain in the sand when the pettern is removed. The pettern for a simple shoring washer is mede in this way.

core assembly When cores are too complicated to produce with ease es e single unit, e core essemhly is made. It is mede up of a series

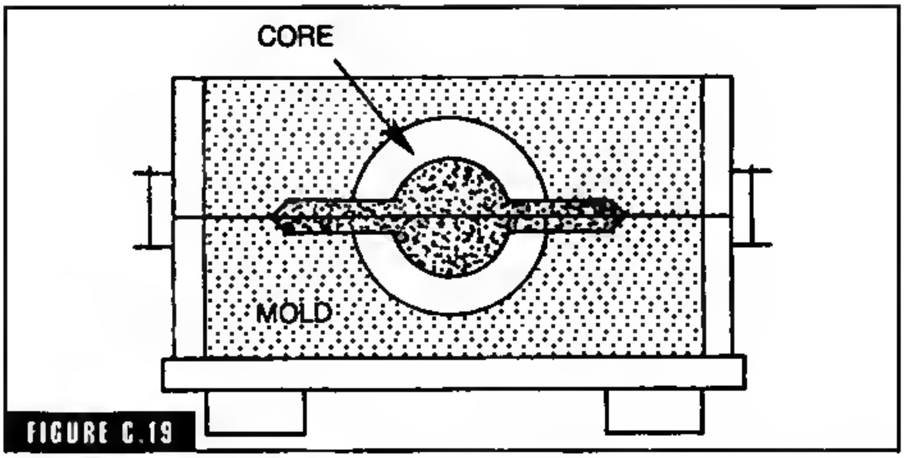


FIGURE C.19

A core is often inserted in the mold.

of cores (parts) and assembled by pasting, leading, bolting, etc. An example of this is the coring for a water-cooled engine block, which is quite complicated but consists of an assembly of simpler cores.

core binders Materials used alone or in combination to bind sand grains together to form a core; the grains are set by chemical action, beat, microwaves, etc. Linseed oil, fish oil, water glass, urea, wbeat flour, cement, dextrin, molasses, bydrol, sulfite, latex, furan, and pitch, are common binders.

core box Wood, metal, or plastic structure that bas the sbape of the desired core to be produced—the female shape of the desired core (male).

core box drawing machine A machine that mechanically draws the rolled over core box from the core. There is a wide variety of machines built. Some roll the box plate and core over and draw the box upward; in others the core plate is lowered from the box. Some are completely automatic and blow the core in the box and draw it. Others are semiautomatic, while some are opereted completely manually.

core daubing Also called *core mudding.* Tbe joints of glued cores are daubed or mudded to make a smooth joint and to prevent metal from finning at the junction. Like paste, daubing can be purchased or bomemade.

Red talc or graphite moistened with water to a soft mud works well, as does 3 percent bentonite, 3 percent dextrin or molasses, and 94 percent silica flour mixed with water to a soft mud.

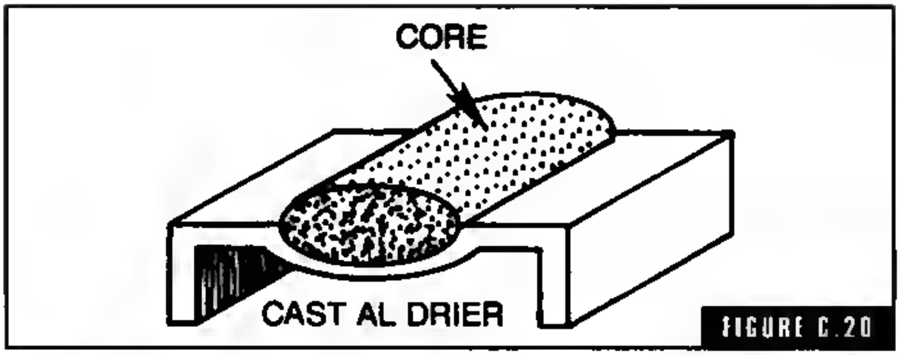


FIGURE C.20

Core drier.

core driers Metal plates that bava the sbapa of tha core to support it and kaep it in sbapa during tha baking cycla (Fig. C-20).

core, green sand A core made of molding sand (not baked) with a core box formad by tha pattarn during molding and used in tha graan state (Fig. C-21).

core grinding With close work, such as engina cores, whare precision is needed, the cores are made oversize at tha joint and ground to tha haight dasirad (Fig. C-22). Tba core grinder consists of a tabla on which the core holding fixture and an adjustabla swing arm grinding whael are attached. When adjusted to the dasired haight, tha grinding wbeal is swung across tha core in tha jig, grinding it to size and at tha sama tima producing a trua and laval surface.

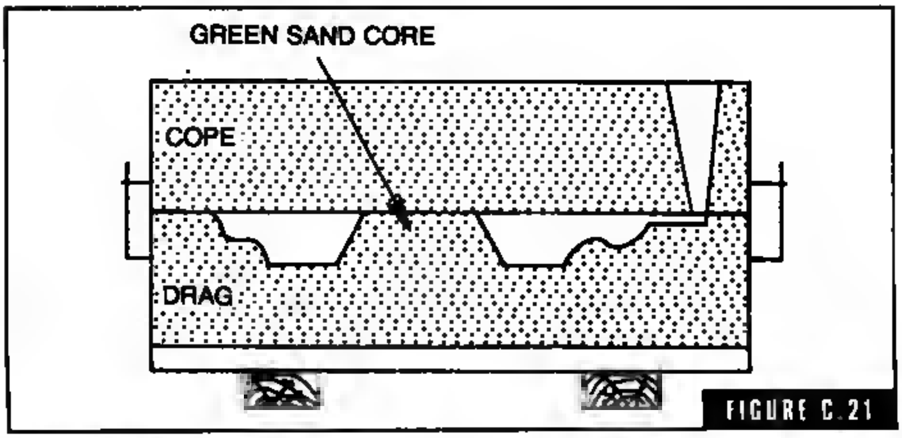


FIGURE C.21

Green sand core.

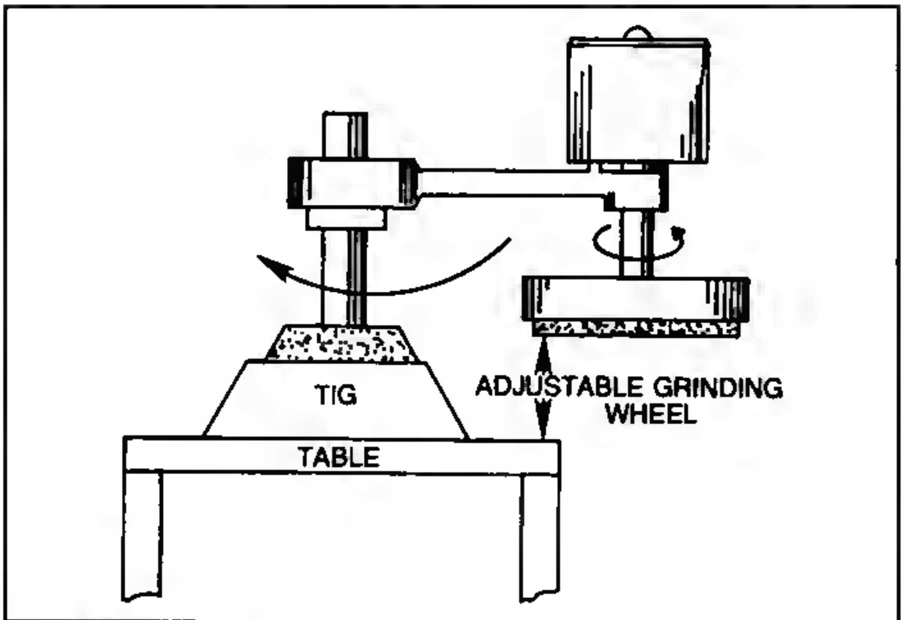


FIGURE C.22

Core grinding.

core hardness The measure of hardness with e core hardness scratch geuge (Fig. C-23). A spring-loaded dial indicetor device similar to e mold hardness geuge. It meesures the dapth of penetration of a steel knife edge es it is drewn ecross the core with tha instrument pressed egeinst the core. The shoe rests on the core. Typical readings:

- Dry sand molds: Soft–20
- Baked cores: Soft–35
- Baked cores: Hard–75
- Dry sand molds: Hard–40
- Baked cores: Medium–50
- Baked cores: Very Hard–90

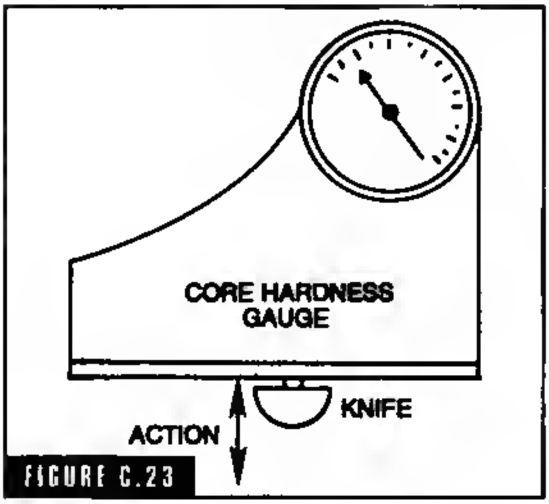


FIGURE C.23

Core hardness.

core hooks Hooks or pat eyes placed in e core; used to lift or handle the core (Fig. C-24).

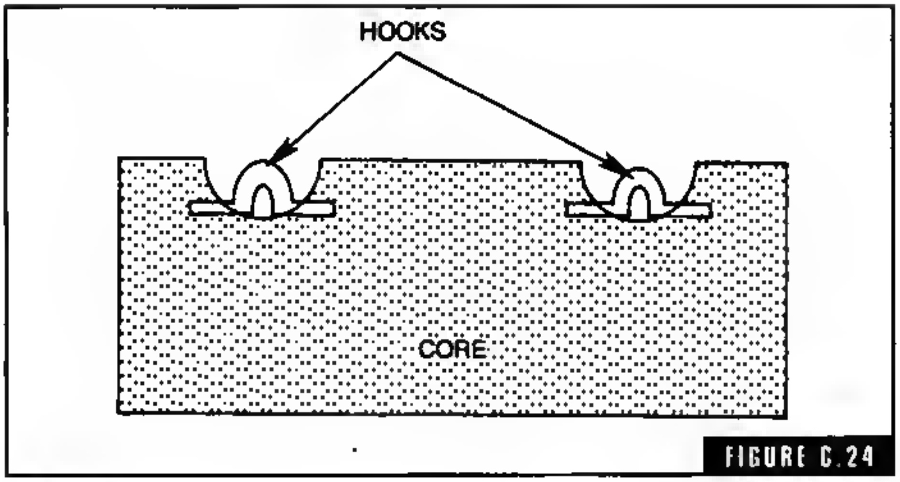


FIGURE C.24

Core hooks.

core maker's trowel The core maker's trowel is exactly like a finishing trowel except that the hlade is parallel its entire length and the nose is perfectly square (Fig. C-25). They come in widths of from 1 to 2 inches in ¼-inch steps; hlade lengths of 4½ to 7 inches long in ½-inch steps. This trowel is used to strike off core hoxes. Because it is parallel and square ended, a core can he easily trimmed or repaired and sides can he squared up.

core marker The print on a core which is so shaped that it can he set in the mold only one way, matching a corresponding shaped print on the pattern (Fig. C-26). Also known es a *keeper* or *key*.

core molds A mold mede entirely of cores; the no-hake molding system is essentially core molds.

core paste A prepared adhesive used to glue and join sections of cores together. You can make your own from weter glass and talc, dextrin, flour, graphite, and molasses; however, it is more economi-

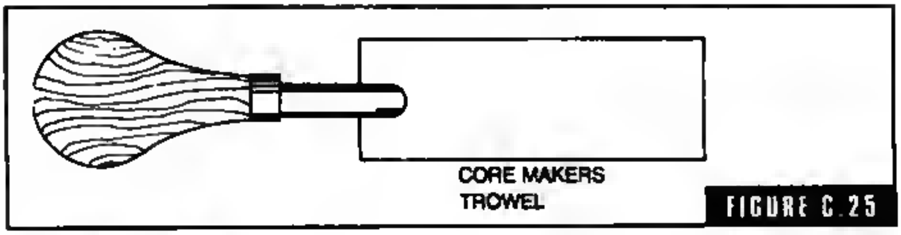


FIGURE C.25

Core maker's trowel.

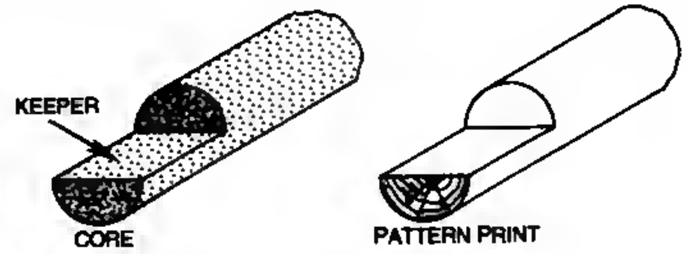


FIGURE C.26

Core marker.

cal to purchasa a prepared paste from a foundry supplier. Thera is a hot paste, sold in stick form. It is applied with an alectric pasta gun, which haats tha pasta and applias it with a triggar action.

core plug A wood or metal form that is an axact reproduction of a dasirad core and its print (Fig. C-27). Tha purposa is to sea axactly

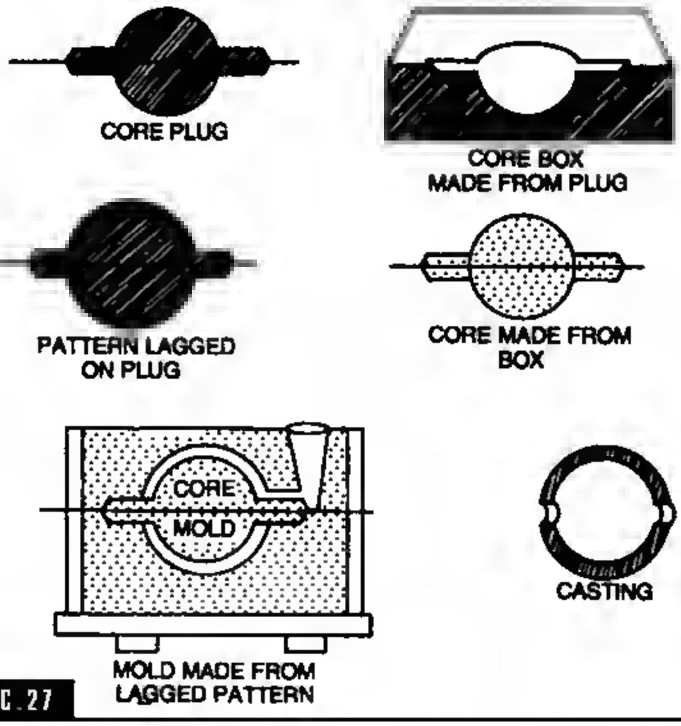


FIGURE C.27

Core plugs.

what the core will look like to determine the construction of the core hox, hoxes, or driers.

In many cases the core plug is used to produce a plaster cast core hox, then lagged to produce a pattern. This is a good quick method where only a few castings are required or a prototype piece.

core print An extension on a pattern which makes a print in the mold cavity used to hold and locate the core in the proper position and alignment in the mold during casting (Fig. C-28). The core print on a core is that part of the core that rests in a print in the mold.

The so-called soft plugs or freeze plugs on the side of your auto engine are in reality cores extended through into prints in the mold to support the core during pouring.

core rise This defect is caused hy a core rising from its intended position toward the cope surface. It causes a variation in wall thickness or, when touching the cope, there is no metal at that point.

The core has shifted from its position. A *green sand core rise* is when a green sand core in the drag is cracked at its base (caused when drawing the pattern) and floats toward the cope. Dry sand cores will float if the unsupported span of a thin insufficiently rodded core is too great. It will hend upward hy the huoyancy of the metal. Insufficient core prints in numher and de-

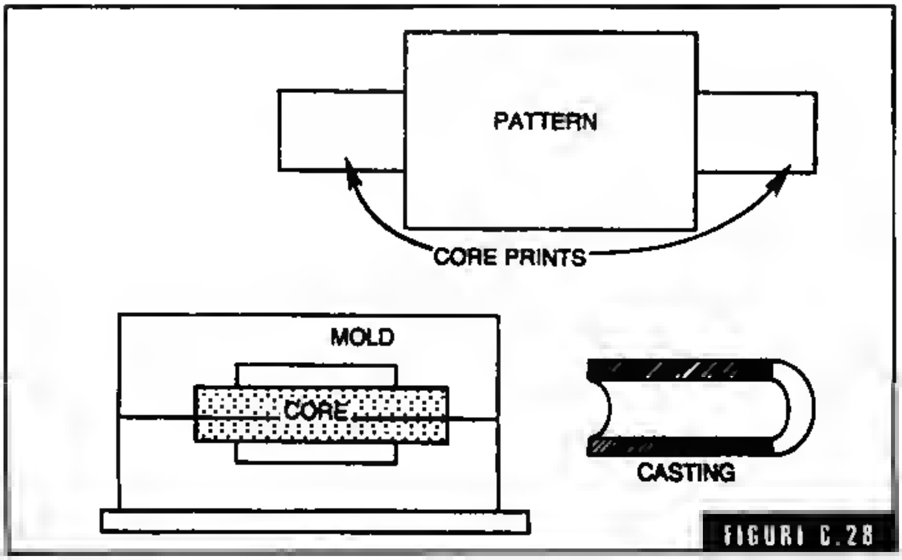


FIGURE C.28

Core print.

sign, insufficiant cbaplets, slipped cbaplet, chaplets left out by molder, or poor design of the core are causes. Tbis defect is easy to spot and remedy.

core rods Rods and/or wires incorporated in tha core during tha coramaking. Thay are used to give the nacassary strength to tha core to prevent it from breaking from the forces it is subjected to during the casting operation. It can be a small wire in some cases or large rods and wires in combination, as ona would use to reinforca concrata in building a wall, atc. Tha size, amount, and complexity are determined by the size of the casting and design of the cored cavity.

core sand Sand free from clay, a nearly pure silica, any sbarp sea sand used to make dry sand cores. Core sand is usually purchased as washed, dried, and graded. When core sand is bonded with clay or bentonita, tamperad and used to mold with, it bacomes molding sand.

core shift Distortion or variation of a cored cavity in a casting due to the core moving (shifting) position, or the misalignmant of cores in assembling (Fig. C-29).

core sizing Checking a core with a template or other gauga to determina its go/no-go tolerance limits (Fig. C-30).

core sweeps Cores produced from a sweep or sweep box in place of a full cora box. Larga cores ara often swept to cut down on the pattern cost (core boxes) (Fig. C-31).

core venting Becausa more oftan than not tha cora is almost totally surroundad by metal, tha natural venting properties of tha core (sand) must be supplamentad by creating additional passages

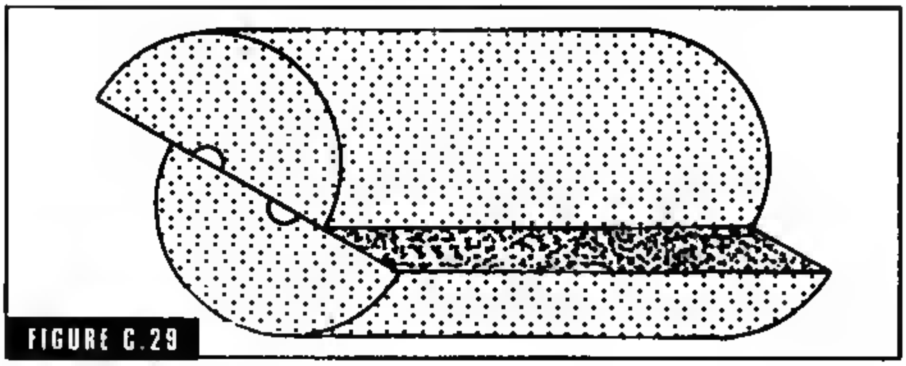


FIGURE C.29

Core shift.

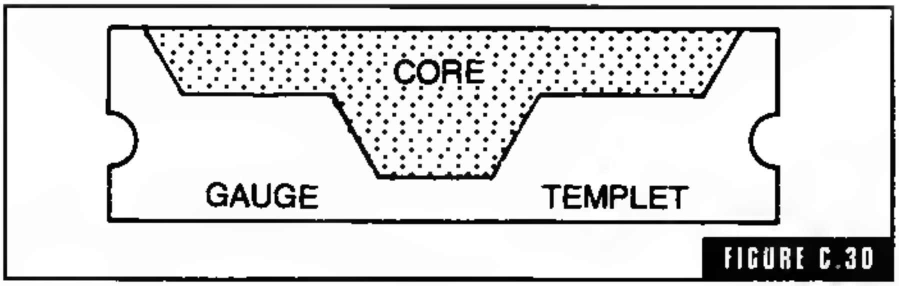


FIGURE C.30

Core sizing.

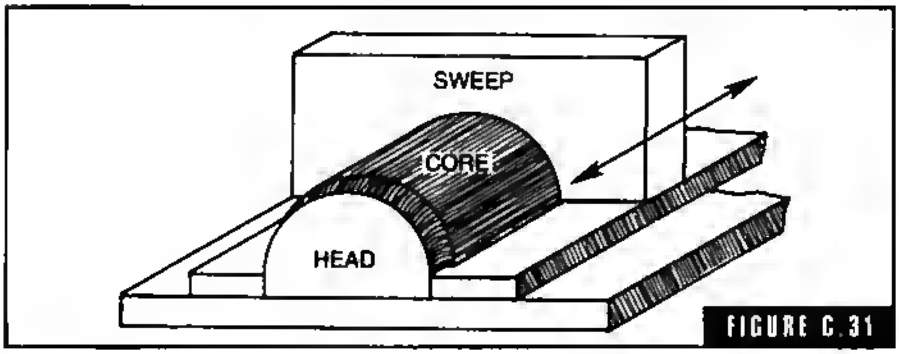


FIGURE C.31

Core sweep.

leading from the interior of the cora through the prints to the outside of the mold.

core vent wax A specially formulated wax used to vent dry sand cores (Fig. C-32). The wax is rammed in place during the coremaking and melts during the baking of tha core, leaving a clean hole or vent in its plece. It is sold in spools in sizes from 1/32 to ¾ round solid, from ⅛ to ¾ round hollow, and 1/32 × ⅛ to ¼ × ¾ flet ovel.

cores baking dielectric Baking cores bonded with urea binders by pessing them through dielectric oven (microwave oven). Typicel core mix suitable for dielectric baking: 500 pounds sbarp sand; 11 pounds urea formaldehyde base binder; 4½ pounds cereal; 1¼ pounds boric acid; 2½ quarts kerosene; and 8 quarts weter.

corrosion The oxidization of e material, like rusting, which is increesed with the presence of heat and oxygen or meteriels wbich contain oxygen sucb es H_2SO_4, sulpburic ecid.

cover core A core that essentially covers the entire mold cavity with the exception of the gete entrance and is held down by the cope and in place hy its print (Fig. C-33). In many cases the cope can be elimi-

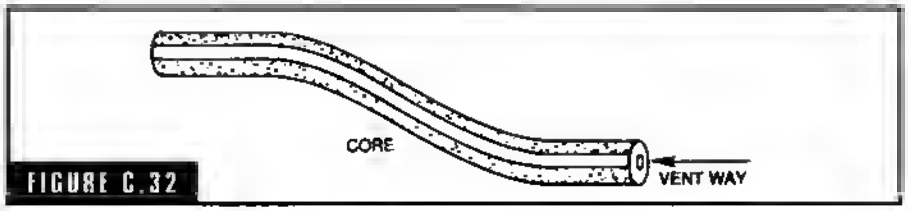


FIGURE C.32

Core vent wax.

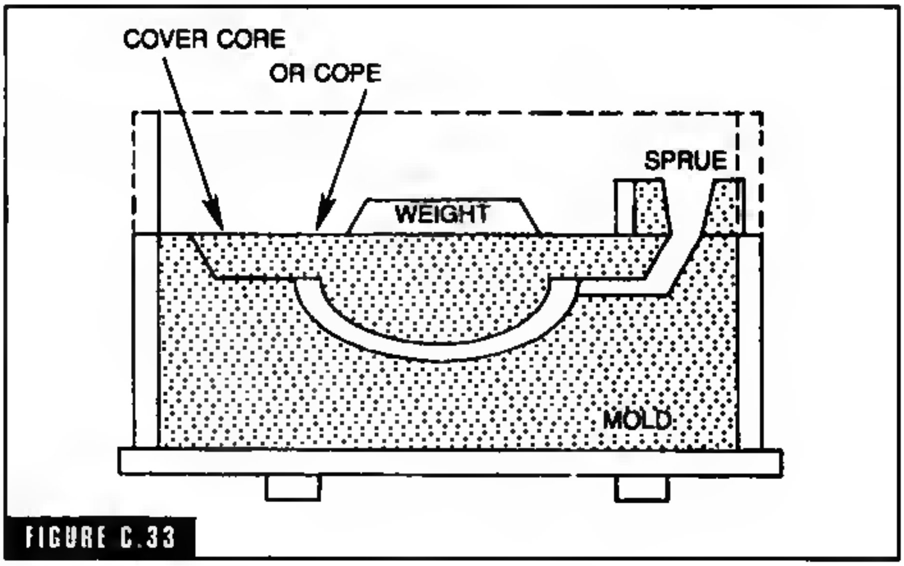


FIGURE C.33

Cover lifts.

neted and a weight set on the cover core. A core sand pouring cup should he used to pour the casting—a great seving in labor.

cover lifts Tin forms used to cast the lifter bridge on stove covers (Fig. C-34). However, the clever engineer or inventor can find many other uses for them.

The tin is dropped into a socket in the pettern and the sand is sucked under the tin. Then the mold is finished. When the pettern is removed, the tin remains in the mold. The metal flows through the inside of the tin forming the crosshar or lifter hridge, performing e task which would be difficult to do with a core.

cracked molds Molds thet are crecked due to improper handling—flesks too weak, weak and rotten hottom hoards, mold sitting on an uneven surfece, loose flask hars. The defects caused hy cracked molds are scabs, run outs, and finning.

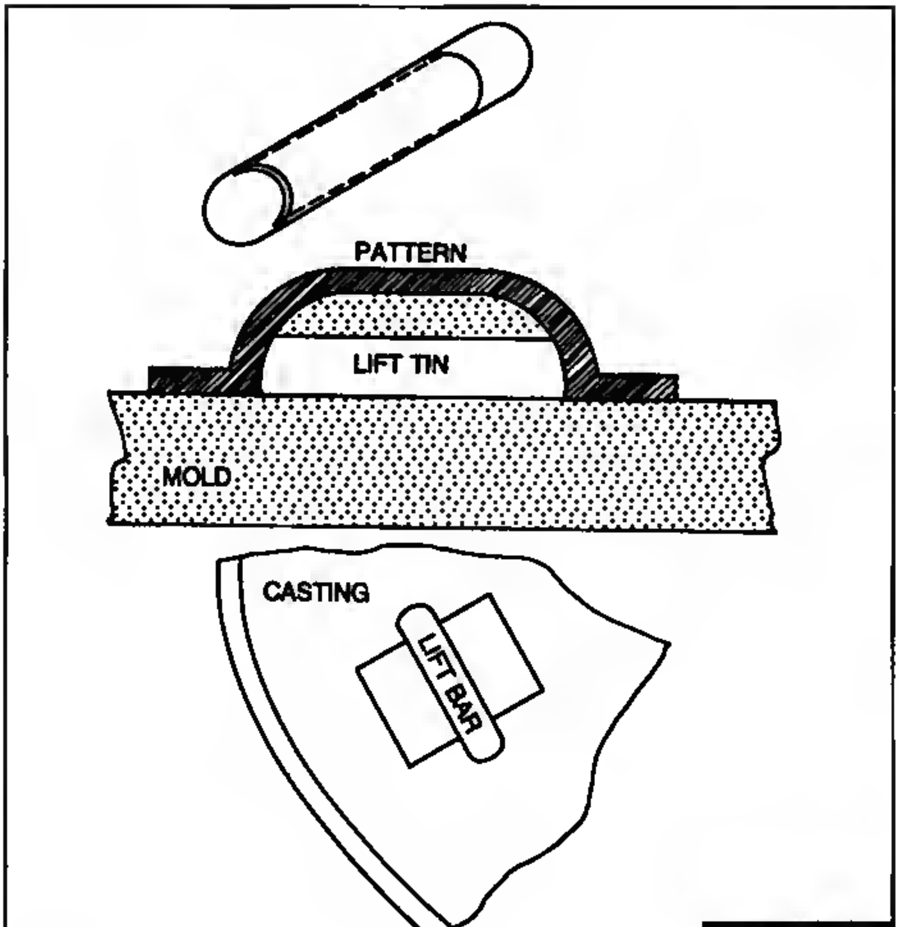


FIGURE C.34

Cover lifts.

creep The slow or gradual distortion of metal under e constant stress.

cribbing Also celled curbing (Fig. C-35). A large mold is surrounded with beavy planks or steel beams and the space between the cribbing is rammed with floor sand to back and strengthen the mold. In solid investment molds this prectice is widespreed due to the fregile cbarecteristics of e calcined mold. Cribbing will also prevent a run out should the mold crack during pouring. Should the mold be lowered into a pit and then supported by rammed sand, the term is *pitting*. Tbe end results are the same.

crucible A large family of ceramic pots or receptecles made of grepbite and clay or cley and other materials such as silicon car-

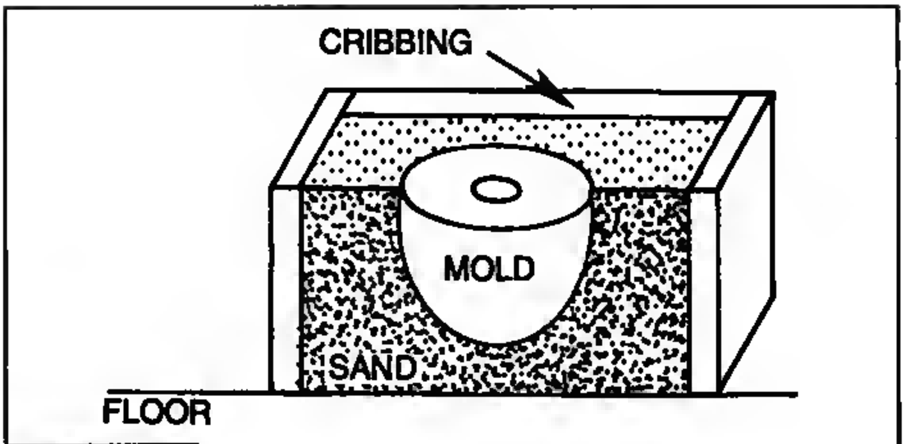


FIGURE C.35

Cribbing.

bide, etc. Used primarily in the foundry to melt steel, iron, bronze, eluminum, etc. Pots mede of iron, steel, and wrought steel wben used to melt in are also referred to es crucibles. Crucibles cover e size range of e few ounces cepecity to 2395 pounds (A #700) and up. Foundry crucibles are standardized by size and number. The rule of thumb is e crucible's cepecity is one times its size number in aluminum and three times in red bress. A number 10 crucible will hold 10 pounds of molten eluminum or 30 pounds of molten brass.

crush This defect is ceused by the ectual crushing of the mold, ceusing indentetions in the casting surfece. It is ceused by flesk equipment, sucb es bottom boards or cores, thet are too tall or too large for the prints or jeckets. Also ceused by rough bandling.

crush strip A strip around e large pettern thet prevents the metching edges of e mold cevity from crusbing wben they meet (Fig. C-36). An intentional flash around the casting. Used on large castings wbere the cope, due to its weight, could twist or sag, preventing the cope from coming down on the drag evenly et all points.

The crusb strip is removed from the casting by chipping or grinding. Any damege done by crusbing will occur eway from the cesting and not into the cevity.

crystobalite A form of quartz with e melting point of 3140 F. crusbed and ground to flour. It is widely used in prepared investments.

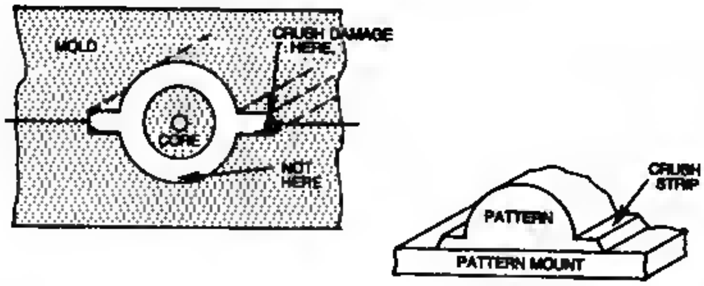


FIGURE C.36

Crush strip.

cupola A continuous melting device primarily for (but not limited to) cest iron, wbicb is in fact and operation e small type of blast furnece lined with refractories for melting the metal in direct contect with the fuel (coke or charcoel) by forcing blast air under pressure through openings (tuyeres) near its bese. The cupole resembles e smoke steck and is often called e *stock*.

cupping The tendency of flat sewed pettern lumber to curl ewey from the heart of the tree (Fig. C-37). This is one reeson wby you sbould buy quarter-sewn pettern lumber.

cut Defects in e casting ceused by the erosion of the sand by the molten metal flowing over the mold or cored surfece.

cutting over Working over floor or beap sand with e molders' sbovel to distribute the moisture, areete, and otherwise obtain e uniform mixture.

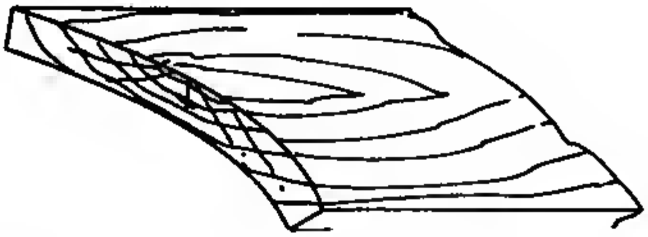


FIGURE C.37

Cupping.

cutting shellac Diluting shellac with alcohol to tha desired consistancy. Dissolving flake shallac with alcohol. Always add a pinch of *oxalic acid* to cut shellac to prevent it from oxidizing and turning black.

D

dam gate A gate constructed with a dam to effect a ready cboke and skimmer (Fig. D-1). It is usually made with a triangular core whicb sets in a suitable print.

damper screw shells Screw sbells are drewn tin shells with e roller thread used for casting a threaded hole (Fig. D-2). Tbey eliminate the cost of drilling and tapping. Because these threads are rolled, they are not satisfactory for a pressure-tight fitting.

The shell is dropped into a hole in the pattern before molding and the inside fills with green sand wben the mold is rammed. Tbe bole in the pattern must be large enough for the shell to draw freely. They can also be used on a core to produce e threeded bole.

daub Refrectory meteriel used to build up and replace the burned back section of the cupole at the melting zone. It consists of fire clay and ganister or e commercial product such as plastic fire hrick. After eacb run of the cupola, this area must ba chipped back to a fresh slag-free lining, and the cupola daubed back to its original diameter et the melting zone. Also used to repair ladles, lips, and furnece linings. Tbe area requiring the repair must be thoroughly cleaned and wetted down and the deubing meterial rammed firmly in place. Tbe deubing mix must be only wet enough to work. Excessive moisture will ceuse the daubing to steam and blow off wben the bed is ignited or wben the cupola is put under blast. Daubing repairs sbould be dried with a torcb or in a core oven. If wet, they will fail or gas the metal in the ladle. It must be done correctly and carefully without rusbing.

decarbonization The loss of carbon from the surface of a ferrous alloy as the result of heeting in e medium that reacts with the carbon.

decrepitation Tbe property of e material or substance to fly epart on being heated (explode).

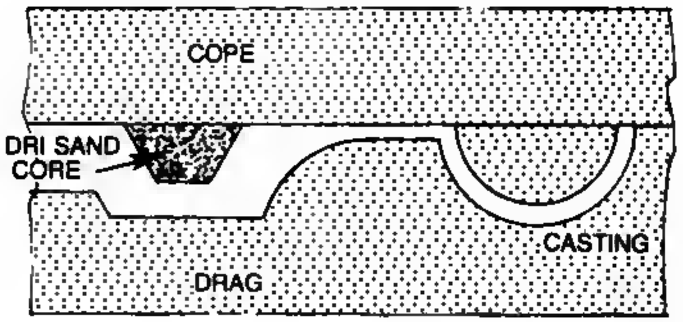


FIGURE D.1

Dam gate.

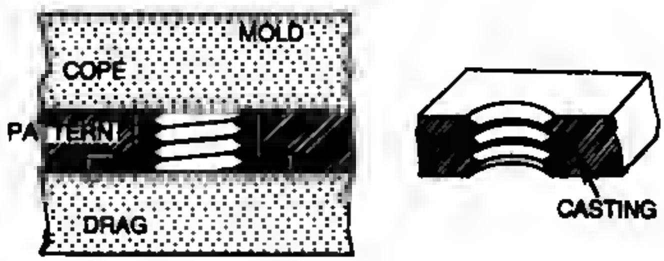


FIGURE D.2

Damper screw shell.

deformation (sand) The change of the linear dimension of a sand mixture when put under stress.

degassing The removal of ebsorbed gasses from e metel bath by chemical or mechanical ection. Deoxidizing red brass with phosphorous copper is e chemical ection. Removing gas from an aluminum bath by bubbling dry nitrogen through it is a mechanical action because the nitrogen bas no cbemical action with the aluminum or dissolved gasses but creetes a mecbanicel vebicle (bubbles) to which the gasses ettech themselves and ride to the surfece and out.

dendrite Tbe crystals formed during solidificetion (Fig. D-3). As e cesting starts to freeze in the mold, the metel in immediete contact with the walls of the mold will freeze first, forming e thin layer of equi-axed crystals. Dendrite crystals then grow or sboot

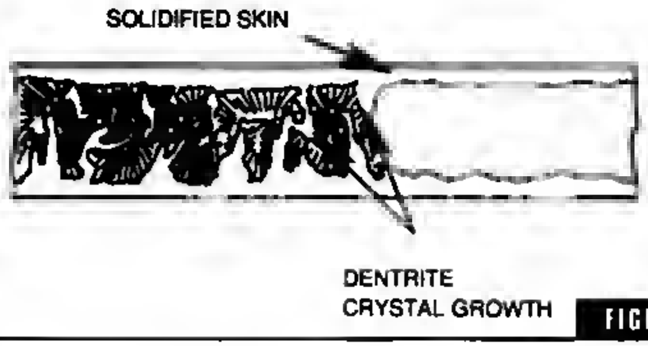


FIGURE D.3

Dentrite.

out from this face into the remaining liquid, forming crystals wbicb look like pine trees.

deoxidize The removel of oxygen from metal oxidas in e beth. When you rob them of their oxygan, they then revert back to metal. Is done by introducing e substance that bes e greeter affinity for oxygen than the suhstance which is oxidized (combined with oxygen) sucb as lithium or pbospborous for copper, aluminum for steel.

density Tha mass of a unit volume of a material et different tempere-tures, measured as specific gravity.

desulphurizing compounds Compounds used to remove or lower the sulphur in molten cest iron prior to pouring. Sulpbur is primar-ily an undesireble element in iron.

The ective desulpburizing agent in both ceustic sode (76 per-cent) and sode esb (58 percent) is sodium oxide. Eighty to 85 per-cent or more of tha sulphur presant in cupola iron can he removed hy a single ladla treetment.

Of the two reegents used to remove sulpbur, sodium carbon-ata (sode esb) is the most used. A good commarcially pure soda ash is best and is sold under various trede namas.

desulphurizing ladle A U-sbaped ladle usually mounted in front of the cupole on trunnions with e tilting mecbanism; used to treet the iron with sode esh to remove the sulpbur (Fig. D-4). The iron is tapped into the ladle, the stream of iron from the cupole spout goes into the ladle through e slot-sheped opening on one end of its insuleted cover, and is then treeted. Iron is poured into the re-ceiving ladles from e tee pot spout on the opposite end by tilting

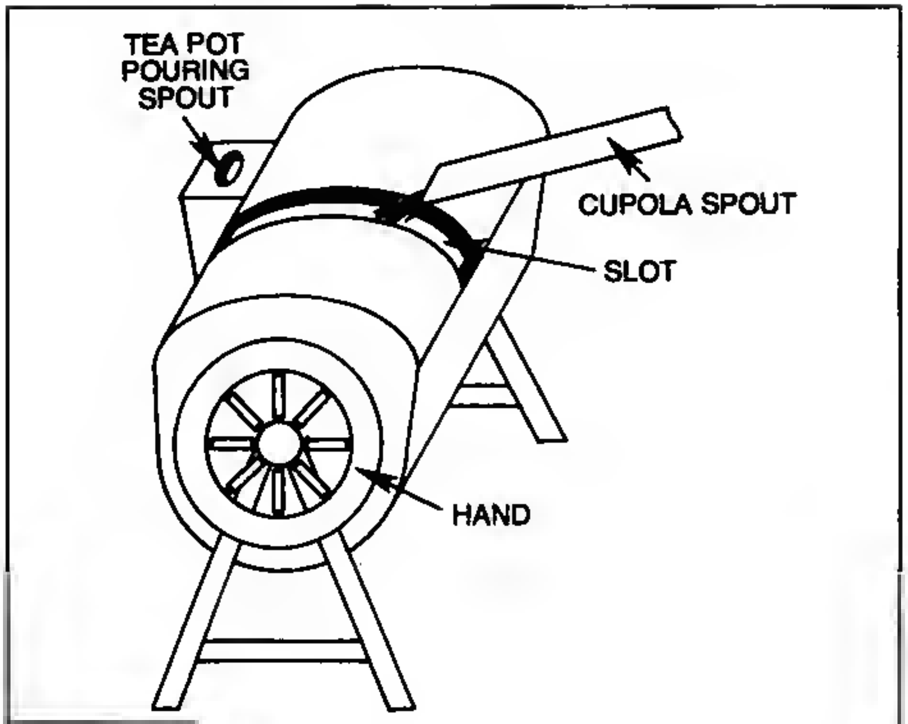


FIGURE D.4

Desulphurizing ladle.

the U ladle. The slot arrangement gives access to the iron coming from the cupola regardless of the angle of tilt. Some loss of temparatura results but is usually offset by the incraase in fluidity of tha desulphurized iron.

dextrin Also called *amylin*. It is a compound having strong adhesive properties; a whita powder, odorless with a sweetish taste, watar soluble. It is made hy tha action of dilute nitric and hydrochloric acids on starch, then heating to 100 to 125 C. It is used as a hinder in skin dried, dry sand molds, core washas, atc.

dezincification Tha loss of zinc from the surface of a zinc-hearing alloy sucb as brass; or zinc corrosion. It is accompanied hy the deposit of a residue of one or more active components—usually coppar.

diffusion The movement of atoms within a solution in a direction from a region of high concentration to one of low concentration in order to achieve homogenity of a solution which may he a liquid, solid, or gas.

die casting Casting into e permanent mold (metal or graphite) hy forcing the metal into the mold cevity under high pressure. A repid method of casting which is highly mechanized and only used where e large volume of castings are needed due to the high cost of dies and mechines. It is limited hy design and metel selection. The most used metal in this case is zinc and zinc alloys.

dirty castings Dirty cestings can come from many ceuses; however, most are ceused hy poor pouring prectices, geting, and sloppy molding. Additional causes include:

- Not skimming properly.
- Getes too large to choke properly.
- Not estehlishing and maintaining e choke.
- Mold cevity not blown out completely and properly.
- Excessive use of dry parting.
- Weak sand.
- Soft molding.
- Wild metel.
- Carhon too high for cesting section (in iron).
- Getes nozzling (spreying) the metal into the cavity.

discs Cheplet shims, plain or perforeted tin pletes used to provide e shim or to provide an edditional hearing surfece to rest the cheplet on in the case where the core is very heevy or subjected to excessive lift when the mold is poured (Fig. D-5).

On the cope side of the core the pletes are simply leid in position prior to setting the cope. On the drag side they are usually pasted to the core with core paste. The peste is either oven- or torch-dried.

dispersion Separation or scattering of fine particles in e liquid medium (deflocculation) used in connection with the fineness test of cley.

dissolved gasses Gasses dissolved hy e metal when heated and/or melted. In most cases they come from the products of comhustion and must he removed hy the proper degassing treetment.

dolomite A type of limestone used in making cement and lime; used es e flux in melting iron in the cupole.

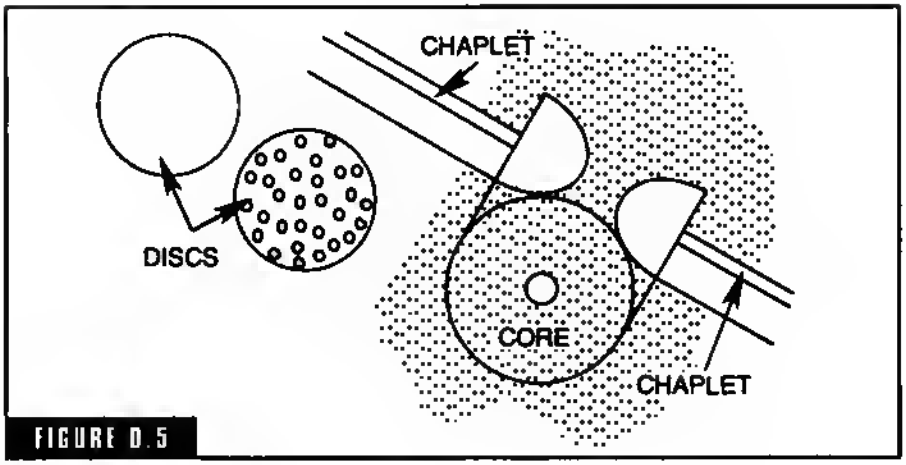


FIGURE D.5

Discs.

double head chaplets Mild steel double headed chaplets, tinned or copper plated, round or square heads.

dough roll A roll made of flour and molasses water and rolled out on a flat board, like clay snakes or large macaroni (Fig. D-6). The dough roll is placed on the drag around the cavity prior to closing the mold. It acts as a gasket or seal to prevent a run out during pouring by taking up any unevenness between the cope and the drag mating surfaces.

dovetails Tin forms which permit the accurate casting of dovetailed grooves, either straight or tapered (Fig. D-7).

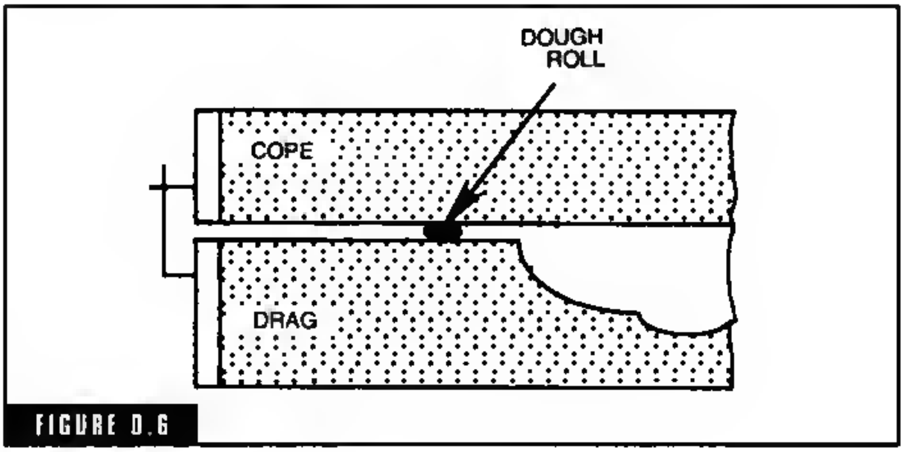


FIGURE D.6

Dough roll.

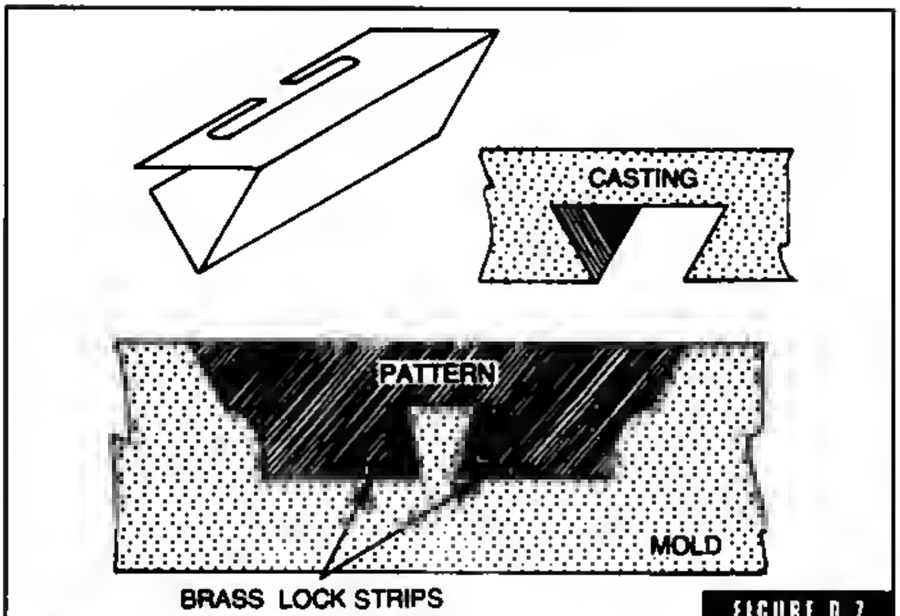


FIGURE D.7

Dovetails.

A brass lock strip is attached to the pattern, which sticks up through a groove in tha tin to locate it and hold it in position during molding.

dowel A pin used to join sections of parted patterns and core boxes to assure the corract registry.

draft Pattern draft is definad as the taper on vertical elements in a pattern which allows easy withdrawal of the pattern from the mold (Fig. D-8). The amount of draft required will vary with the depth of the pattern. The general rule is ⅛-inch tapar to the foot, which comes out to about 1 degree; on shallow patterns, such as a disc, a $\frac{1}{16}$-inch taper of 0.5 degree is sufficient.

drag The lower or bottom section of a mold or pattern.

draw back A section of a mold that must be lifted away on an arbor or plate to facilitate the removal of the pattern (Fig. D-9).

draw bolt A threaded eye which fits a matching thread in a plate (*draw plate*). It is let into a pattern and used to lift (draw) the pattern from the mold or otherwise handle it (Fig. D-10).

drawing Removing the pattern from the mold. Removing a core box from core.

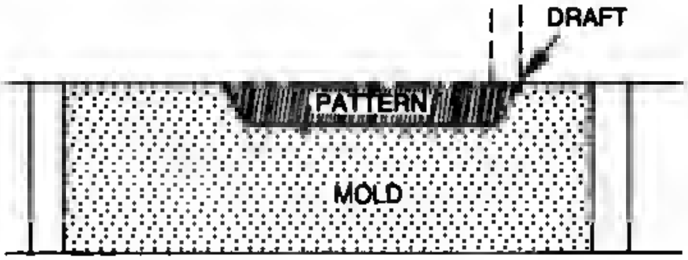


FIGURE D.8

A draft.

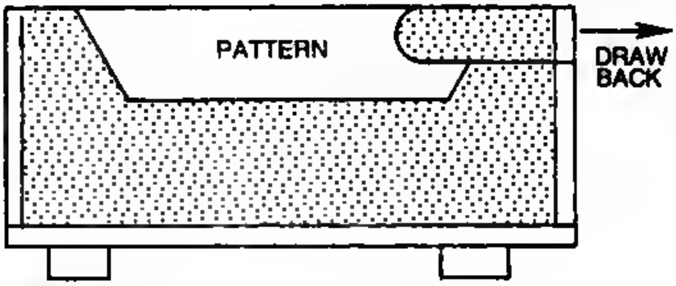


FIGURE D.9

A draw back.

draw pins, screw, and hooks These items are used to remove or draw the pattern from the mold (Fig. D-11). The drew pin is driven into the wooden pettern and used to lift it out as a handle. On a short small pattern one pin in the center will do it. If the pattern is long, use one on each end for a two-hand straight lift. The draw hook is used the same wey. The draw screw is screwed into the pattern for a hetter purchase on heavier petterns and prevents the pettern from eccidentally coming loose prematurely and falling, damaging the mold, pettern, or hoth. In large petterns, plates are let into the pattern et its parting fece. This has a tapped hole into which a draw pin with a matching thread is screwed for lifting by hand or with a sling from a crane. Two or more are used.

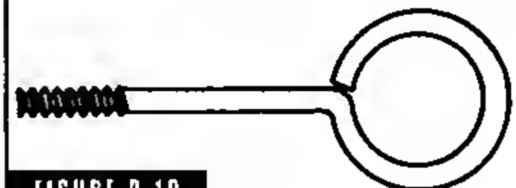


FIGURE D.10

Draw bolt.

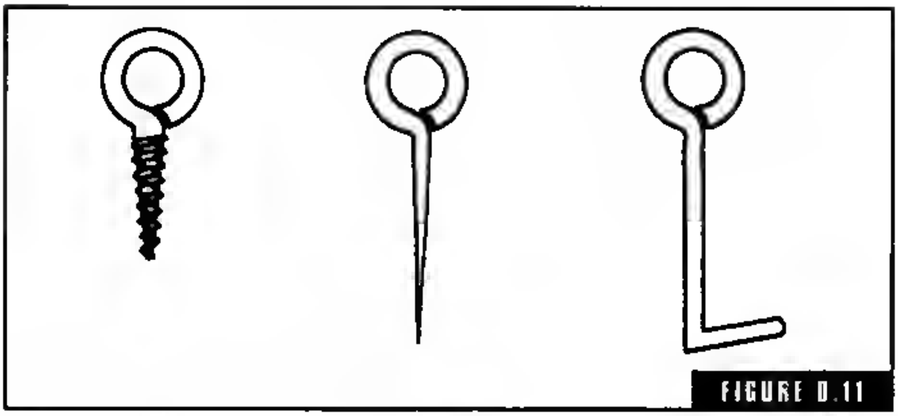


FIGURE D.11

A. Draw screw; B. draw pin; and C. draw hook.

Metel patterns, if loosa, are drilled and tapped to receive a drew pin.

draw plate A plete or device sometimes etteched to tha pattarn to assist or facilitate the drewing of the pettern from the sand (Fig. D-12). A vihreting guide plete used to draw a cora hox from tha core. In soma cases it is a simple cutout in a plete through which the pattern is drewn.

draws A shrinkage or draw et the point where the gete joins the casting (Fig. D-13). A common form of defect on chunky yellow hrass castings. By edjusting the geting and filleting, it can usually be overcome.

draw stick A pointed hardwood stick used to drew smell light petterns from e mold.

driers (ladle) Heeting davices used to dry ladla linings and preheat them (Fig. D-14). They can he electric or gas and oil fired. The lining must he dry and if the ladle is not heeted high enough prior to tapping metal into it, a great loss of metal temperature will occur and the ledle will scull over or freeze.

driers (sand) Any device used to dry wet sand; these may he fired with coal, gas, oil, or electricity (Fig. D-15). Some are continuous driers. The sand tumbles through a heated and inclined revolving cylinder. Others have a simple coal- or coke-fired pot helly stove arrangement with a drying jecket around its circumference.

drops A portion of the cope sand drops into the mold cevity before or during pouring. The causes are humping with weights, rough

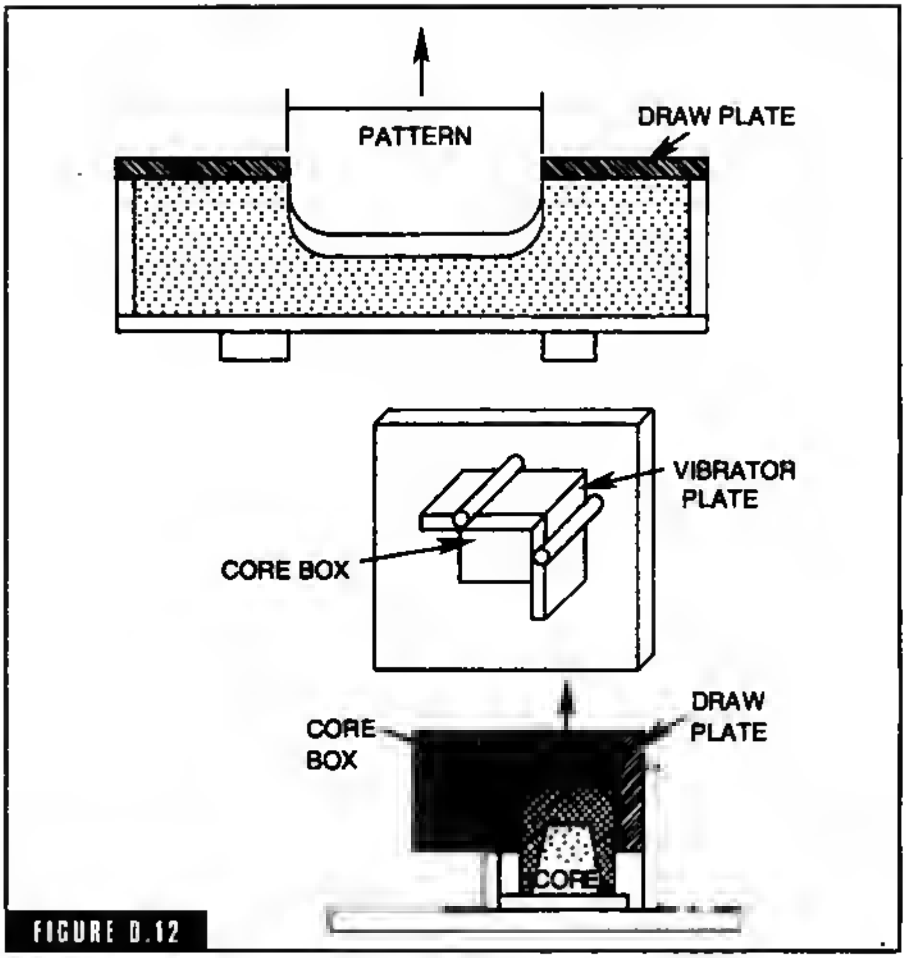


FIGURE D.12

Draw plate.

clamping, weak molding sand (low green strength), rough closing, and jackets placed on roughly, etc.

dross Metal oxides on e molten metal bath or es e defect found in and on the surfece of e casting due to improper geting, melting prectice, or deoxidizing treatment.

dry binders Binders used in core and mold making. They are dry. Includes a wide variety of prepared dry binders such es lion binder, truline binder, flour, rosin, wheat flour, corn flour, cley, pitch, goulac, etc.

dry sand molds Any mold thet hes been dried (baked) prior to pouring. Core molds and furan no-bake are also sometimes called dry sand molds. Although they are dry (no free moisture), they should be celled by their respective names.

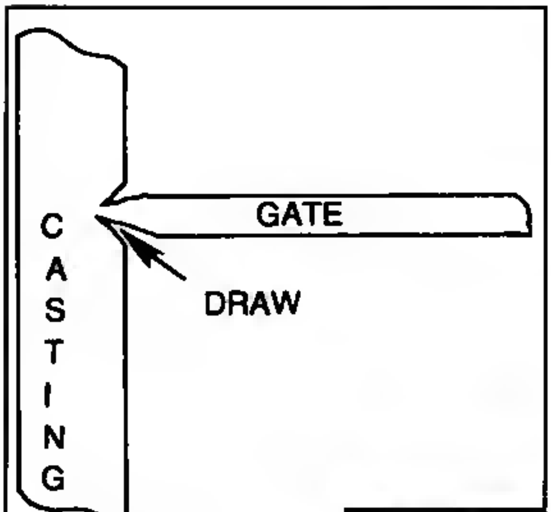


FIGURE D.13

Draws.

Dry sand molds are produced from green sand (system sand) or bonded crude silica sand or e combination of the two to wbich e baking type binder is added to provide e bond when the mold is dried. This bond can be pitch, oil, cereel, etc., alone or in various combinations.

The molds are pleced (open) in e mold drying oven and dried at 350 to 450 F. overnight. They are allowed to cool, cored, closed up, and poured.

Typicel dry sand mixes:

- Heavy bress—system sand tempered with glutrin water (1 pint glutrin to 5 gallons water), 5 percent pitch by weight, baked until dry.

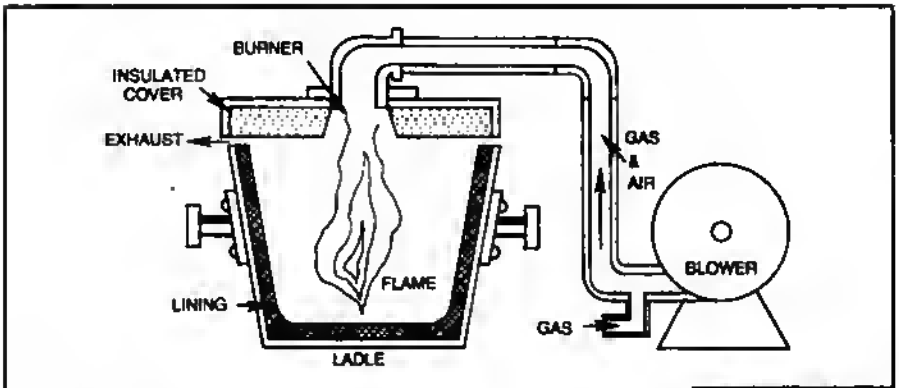


FIGURE D.14

Driers dry ladle linings.

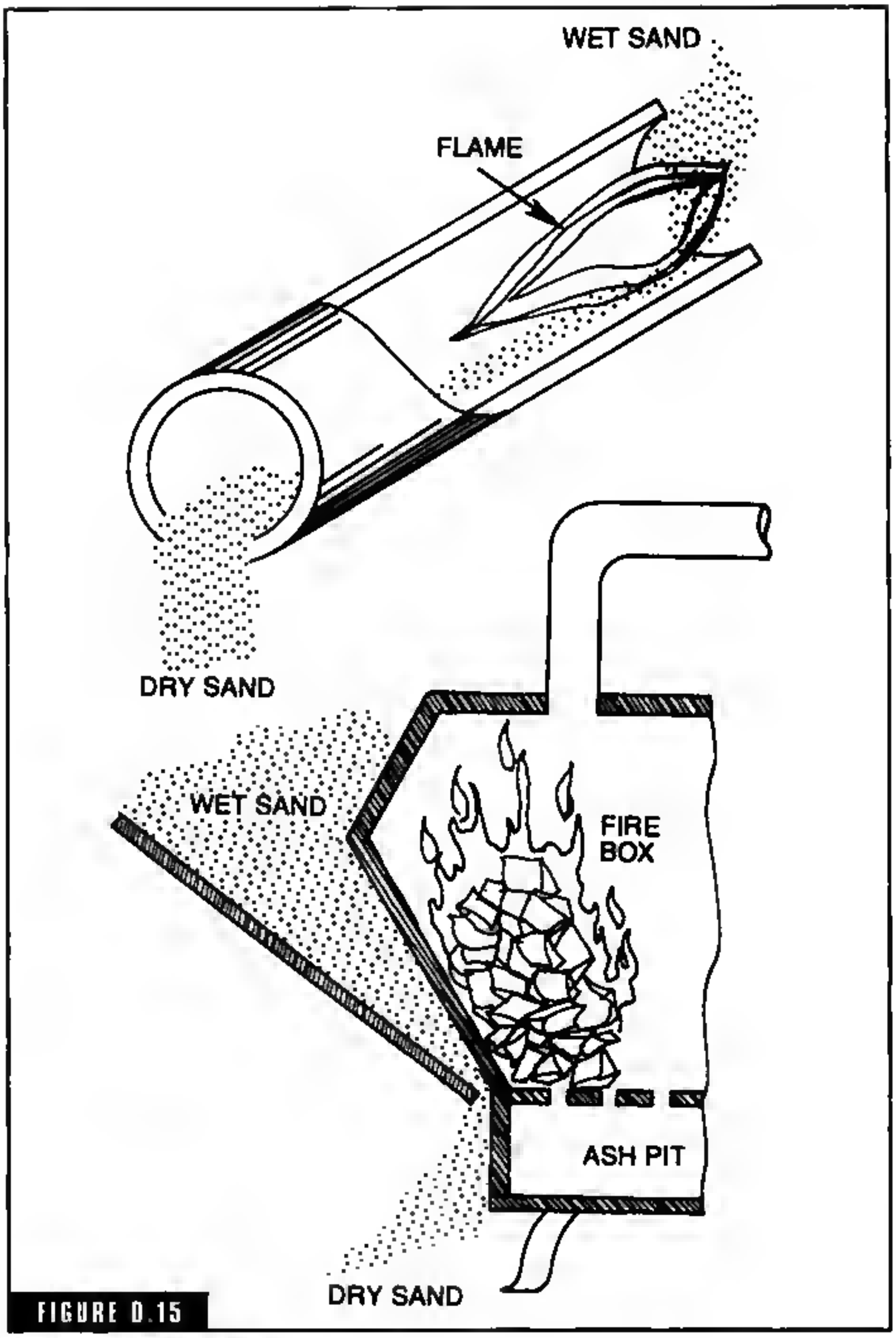


FIGURE D.15

Driers also dry wet sand.

- Medium to beavy grey iron—60 gallons dry beap sand (floor or system sand); 30 gallons crude dry silica sand; 4 gallons bentonite; 3 gallons pitch.
- Heavy phosphor bronze—naturally bonded molding sand, 25 gallons; river sand, 10 gallons; wbeat flour, 1 gallon; blue clay water, 30 to 40 baume. Bake at 450 F. until dry.

dry strength A mold must not only hold its sbape in the green state, but it must also bold its shape in the dry state. Tbis is an important property and is measured as dry compression by allowing the test specimen to dry out before testing, the testing is then carried out in the same manner as for green strength. A good average figure is 30 pounds per square inch. Dry strength should be no bigher than necessary. Excessive dry strength results in a critical sand. If the molding sand bas a too bigb dry strength it will not give or break down as the casting shrinks during solidification.

ductile iron Also called *nodular iron*. A cast iron where the grapbite distributed througb a ferritic matrix is spberoid or nodular in sbape instead of flat flakes in a matrix of pearlite and ferrite. It is produced by adding (treating) the molten iron with an alloy of magnesium, copper-ferrosilicon, or a nodulizing alloy marketed by various firms for the introduction of magnesium into iron. Tbe treatment leaves up to .08 percent residual magnesium in the iron. The free graphite in ductile iron in spberoid (ball) sbapes gives the iron its ductile characteristics.

ductility The measure of the degree of permanent deformation (elongation) a metal or material will take before fracturing or breaking.

dune sand Wind blown deposits of sand—90 percent silica, usually located near large bodies of water, but not necessarily.

durability The measure of the sand's ability to withstand repeated usage without losing its properties and to recover its bond strength after repeated usage. The sand's fineness and the type and amount of clay bond determines the sand's durability. The ability of the bonding clay to retain its moisture is also an important factor.

dust bag Pourous cotton cloth bags used to apply dry parting and facing materials to a sand mold.

E

electric riddle An electrically powered riddle. See also gyratory riddle.

electrodes Welding rods used for electric welding and carbon rods used in the arc furnace for melting.

elongation The amount of extension in the vicinity of the fracture in the tensile test. It is expressed in percents of the etandard geuge length of 2 inches (Fig. E-1). The coupon sample used to test the tensile etrength is first marked off with two center punch marks 2 inches epart. The coupon is pulled (stretched) until it breaks on the tensile strength machine, giving the tensile strength. The two ends of the sample are then fitted together et the point of fracture and the distance between the punch marks measured to determine the percent of alongation.

ethyl silicate A silicic acid used as the principal binder for ceramic investment molds. The normal content of ethyl eilicate is 25 percent available silice. Water hydrolyzes ethyl silicete to alcohol and silicic ecid which dehydrates to an edhesive amorphous silica.

etching Attacking e highly polished metal sample surfaca with a weak ecid or other corrosive agent (ceustic soda for eluminum). The etching agent ettecks the various constituents of the metal unequally so that when the etchant is removed by washing and drying, it can be examined under e microscope or, in some cases, by eye.

eutectic The alloy structure of two or more solid phases formed from e liquid eutectically.

A pure metal's solidification temperature may be lowered by edding another metal. The reduction of the solidification temperature is proportional to the amount edded, up to a point. The solidification range of e high copper alloy such as 95 percent copper would run somewhere in the neighborhood of 1850 to 1700 F. against 1800 to 1580 F. for a similar alloy with only 58 percent copper.

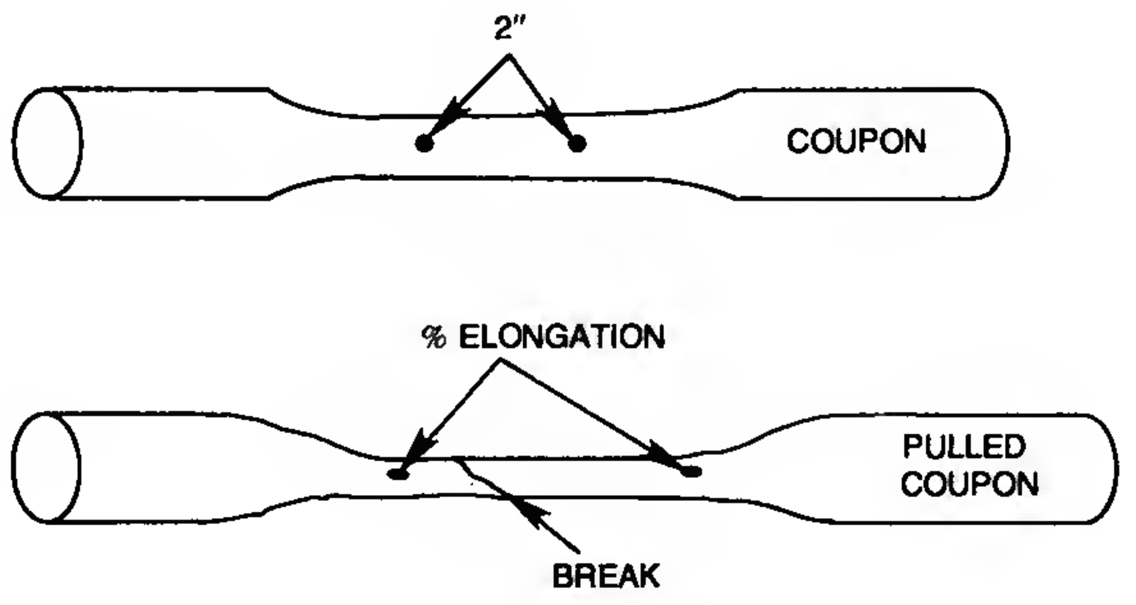


FIGURE E.1

Elongation is the amount of extension of the vicinity of the fracture.[1]

If wa edd sodium chloride (salt) to water wa lower the freezing point of the water. Then as the freezing point is reached, the ice crystals (salt free) make the remaining unfrozen portion higher in salt content, reducing the freezing point still further down the scale. When we reech this point by lowering the temperature when ice crystals start to form again, the same thing happens until we finally reach the point where the water and salt freezes. This final frozen mass of frozen ice and salt crystals is the eutectic. The *eutectic temperature* is the point where this freezing happens.

It is the basis of equipment used today to determine the carbon, silicon, and total carbon of a sample. You pour a sample of molten iron in a special cup containing e thermocouple and plot the solidification curve. The curve is displayed on e digital LED reedout in percents of carbon, silicon, and total carhon of cast iron. This method is called *thermal analysis*. It is the measurement of the cooling curve of e solidifying iron sample and the electronic interpretation of the curve in terms of carbon, silicon, and total carbon.

exoband A sodium silicate (water glass) binder used in the carbon dioxide mold and core bonding system.

expansion The dilation or increase of size thet sand or matter undergoes when heated.

expendable pattern As in lost wax casting, the pattern is lost. Expendable patterns for sand casting are styrofoam and shaped to the desired form with ettached styrofoam gates, runners, and risers. The styrofoam pettern is molded with dry, clay-free sharp silica sand in a box or steel frame. The pattern is vaporized by the metal poured into the mold, leaving the casting.

F

facing The leyer of sand eurrounding the mold cavity. When e mold is made using e specially prepared molding sand in the mold immedietely over the pattern to produce e smoother casting surface or e more refractory surface for the metal to lie against. It is then backed with system or floor sand. It can be simply new or finer sand or sand containing e bond such as flour or pitch (Fig. F-1).

false cheek Making e mold from e pettern which would require e cheek only if done in e two-part flask by double rolling the mold (Fig. F-2). The cope half of the mold is made first, rolled over and the portion of sand which would normally be in the cheek is formed. The drag is rammed against the cope and false cheek, removed, and the drag half of the pattern is then drawn. The drag replaces the false cheek. The mold is then rolled over and the cope removed. The cope section of the pattern is removed from the false cheek and the mold is closed.

false core A core made of green or dry sand to take care of an undercut on e pettern; it is removed and glued or wired in position in the mold proper.

The core is made by tucking the sand into the undercut (back draft) and forming e print on the core. When the mold is rammed, the false core will leeve e corresponding female print into which it ie secured.

fasteners, corrugated Corrugated (nails) fasteners used in pattern construction to secure stock together when turning e split pattern (Fig. F-3).

fatigue The tendency for e metal to crack or break under conditions of repeated cyclic stressing—bending back and forth, vibrating, continuously working.

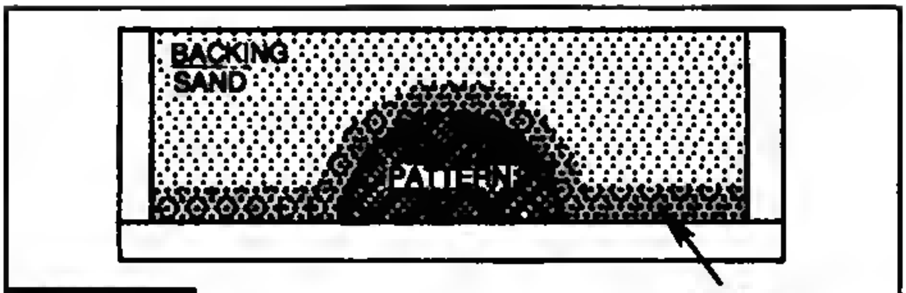


FIGURE F 1

Facing sand.

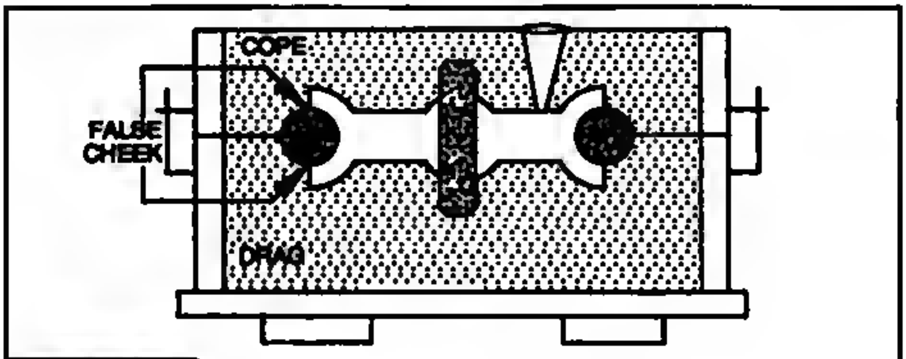


FIGURE F 2

False cheek.

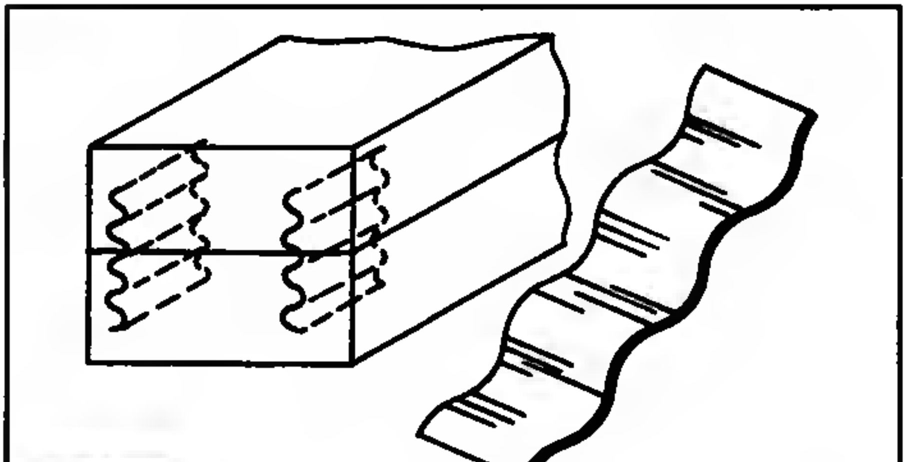


FIGURE F 3

Corrugated fasteners.

feeder A reservoir of molten metal to make up for the contraction of metal as it solidifies. To prevent shrinkage cavities in the casting (voids caused by lack of feed metal) as a riser or head.

feeding Pouring additional molten metal into a freshly poured mold to compensate for volume shrinkage while the casting is setting. Also referred to as *topping off* or *hot topping*.

feel of molding sand Tempering a molding sand to the point that it feels correct. Regardless of the amount of instrument checks, a good feeling sand usually rams easier and better. This skill of telling when a molding sand is right comes only with experience and practice.

ferrite Pure iron consists of ferrite crystals, which are only slightly attached by the usual etching agents except at the grain boundaries.

ferro alloys Alloys of iron and another element or elements (other than carbon) when used as a raw material in the manufacture of ferrous metals.

ferro boron An alloy that is 10 percent boron and 90 percent iron.

ferro chromium An alloy of iron and chromium containing from 66 to 72 percent chromium and .06 to 7 percent carbon. Used to add chromium to a metal bath.

ferro manganese Iron manganese alloy containing over 30 percent manganese; used to introduce manganese in a metal bath.

ferro molybdenum An alloy that is 58 to 64 percent molybdenum and the balance iron.

ferro phosphorous An alloy of iron and phosphorous used to add phosphorous to steel to make phosphorous steel.

ferro silicon An alloy of iron and silicon used for the addition of silicon in iron and steel baths.

ferro titanium An alloy that is 17 to 38 percent titanium, with the balance iron.

ferro vanadium An alloy that is 35 to 40 percent vanadium, with the balance iron.

ferrostatic pressure The pressure of the liquid steel poured into a mold. As long as the metal remains liquid this pressure is equal in all directions.

ferrous Alloys in which the predominant metal or solvent is iron.

fillet irons Steel or brass tools with each end being ball shaped. The ball is used to apply wax fillets to patterns (Fig. F-4). They are

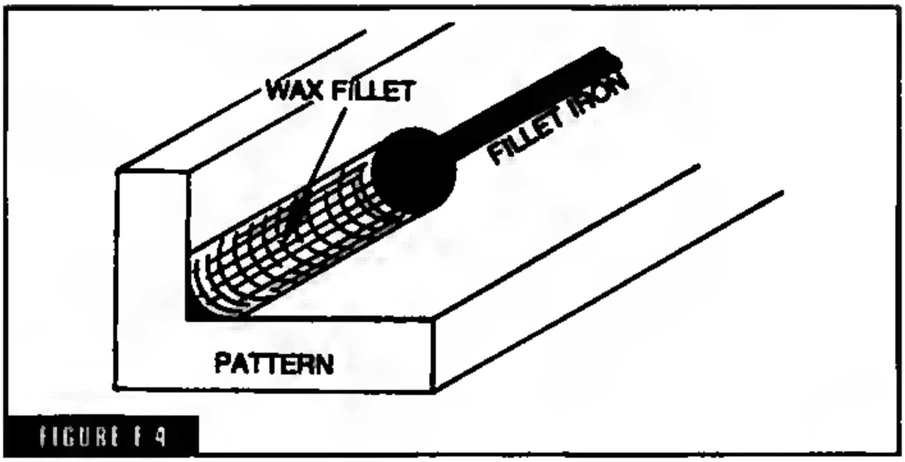


FIGURE F-4

Fillet iron.

sold singularly or in sets from $\frac{1}{8}$-inch ball to $\frac{3}{4}$-inch ball. Each tool consists of two different size balls. A number 2 tool has a $\frac{1}{4}$-inch ball on one end and a $\frac{3}{8}$-inch ball on the other end. The tool is warmed over an alcobol lamp and the fillet is rubbed into place, using the tool with the radius corresponding to the selected fillet.

fillets Patternmaker's fillets are made of wax, wood, paper, or leather and are used to form a radius on a pattern or core box (Fig. F-5). Wax fillets are applied with a fillet iron. Paper, wood, and leather fillets are glued in place. The choice of which type of fillets to use depends upon the end use of the pattern. For a pattern used only for a limited run now and again, wax is fine; if it is a master from which metal production patterns are to be made, where if the pattern is large or to be used quite often, wood or leather might be the better choice. For small to medium patterns of jobbing work, 90 percent are filleted with wax. Paper fillets went out of use some time back but are available. Wood fillets can be used for straight runs only. They are cut slightly over 90 degrees with the back relieved so that they will form a good tight fit when installed.

One-half to 1-inch leather fillets are shaped like wood fillets with a relief at the 90-degree junction. Wood fillets are, in some cases, glued and bradded into place. Never use brads on leather fillets as they draw the leather and make an uneven surface.

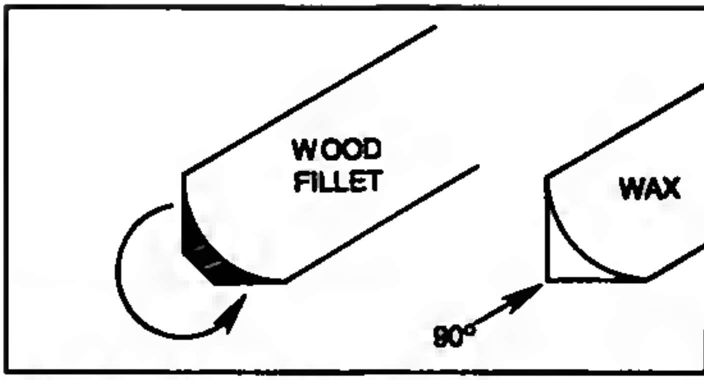


FIGURE F 5

Fillets can be made of wax, wood, paper or leather.

When applying fillets to e pattern or core box there is e tendancy to rush it—*don't.* You should apply the fillets with the same care as in building the pattern.

film on metal When metal falling from a single gate has to climb e hill to fill the other side of the mold, oftentimes e film is formed whan tha metal in the first valley stops momentarily then spills over into the second valley (Fig. F-6). This temporary halt will cause a reflected cold-shut and in some instances a sufficient film will form on the halted metal to separate part of the casting into layers. Two or more gates should be provided so that none of the metal has to rise over e hill and then run down into the valley on tha other sida. A gate leading into each valley will allow tha mold to fill uniformly.

filters A pad of coarse steel wool placed at the bottom of tha sprua when casting magnesium to eliminate vortex ection of the metal stream and assist in filtering out oxida skins (Fig. F-7). Slot sprues are used in casting magnesium to prevent vortex.

fin This defect is e fin of metal on tha casting caused by e crack in tha copa or drag. It is caused by wracked flasks, bad jackets, uneven warped bottom boards, uneven strike off, insufficient copa or drag depth, bottom board not properly rubbed, or drag mold sitting unevenly (rocking).

fineness A measure of the actual grain sizes of a sand mixture. It is made by passing e standard sample, usually 100 grams, through a series of graded sieves. About 10 different sieva sizes are used. Because most sands are composed of e mixture of various size

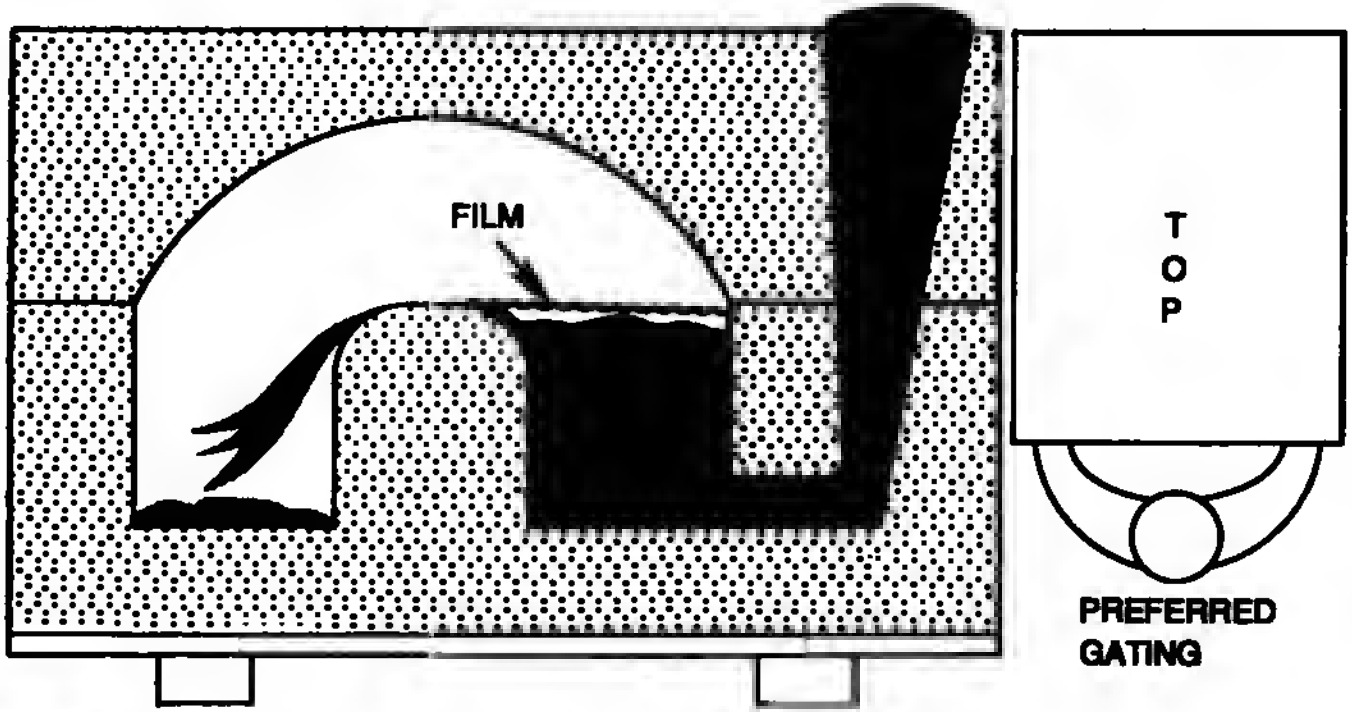


FIGURE F 6

Film on metal.

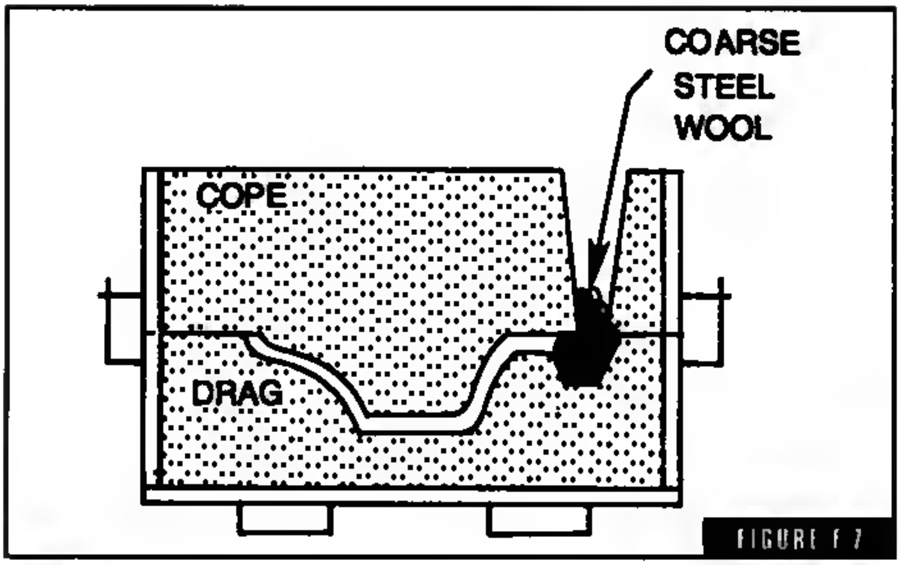


FIGURE F-7

A filter.

grains there is a distribution of sands remaining on the measuring sieves.

The fineness number assigned to the sample is the number of the sieve through which the largest amount of sand passed.

finger gates Multiple gates into a casting from a single runner (Fig. F-8).

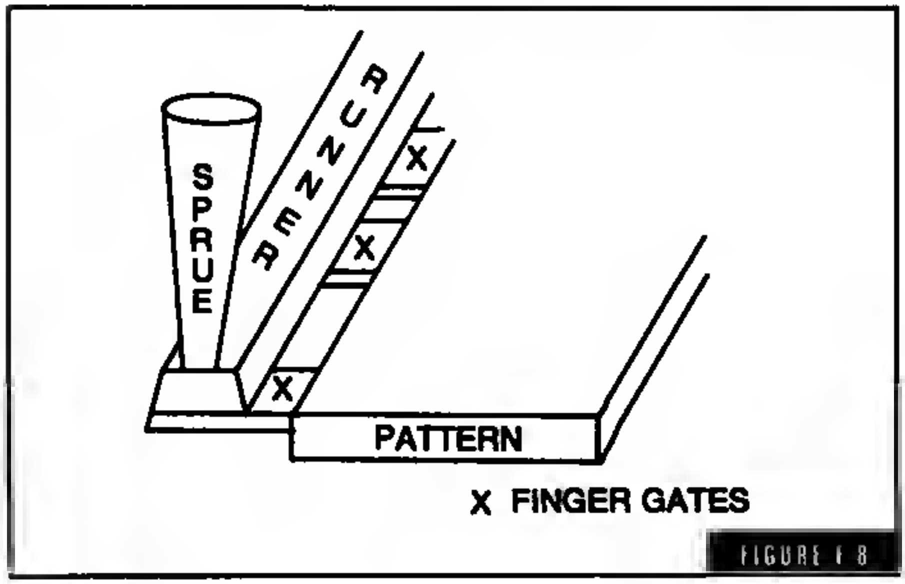


FIGURE F-8

Finger gates.

finish allowance The amount of extra stock left on the surface of a casting for machining plus shrinkage compensation.

finish mark The symbol in the form of an *f* appearing on a line of a print or drawing indicating that the marked edge of the surface of the casting is to be machined finished. It indicates the need for additional stock at the point or surface indicated.

finishing trowel The finishing trowel is used for general trowel of the molding sand to sleek down a surface, to repair a surface, or cut away the sand around the cope of a snap flask (Fig. F-9).

fire brick Bricks made of clay with a fusion point no less than 1580 C. or 2878 F.

fire clay Any clay with a fusion point not less than 2768 F.

fitted head chaplets A stem chaplet in which the head is fitted or shaped to fit a particular shape (on the core) (Fig. F-10).

flange A stiffening member or a means of attachment to another object (Fig. F-11).

flat back patterns Patterns that are flat on the side presented to the cope and do not extend into the cope of the mold. The entire mold cavity is in the drag (Fig. F-12).

flame annealing The process of softening a metal by heat from a high-temperature flame.

flame hardening The application of heat to a metal from a high-temperature flame to quenching (cooling as required).

flare point The temperature of a metal such as yellow brass and high strength yellow brass (manganese bronze) where the zinc flares send little pips of zinc oxide from the metal surface. Low tensile

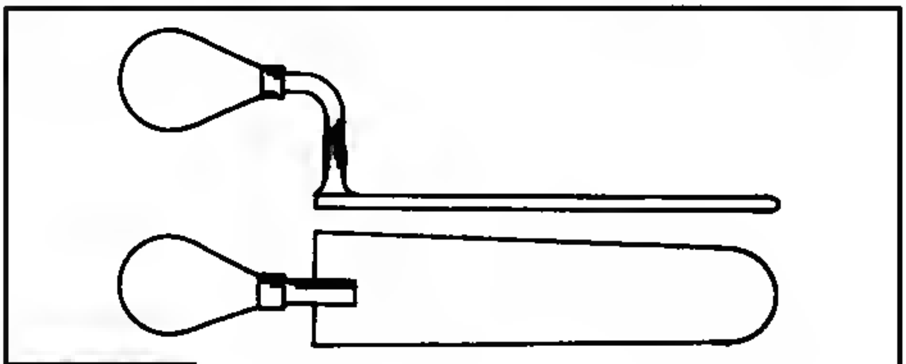


FIGURE F-9

A finishing trowel.

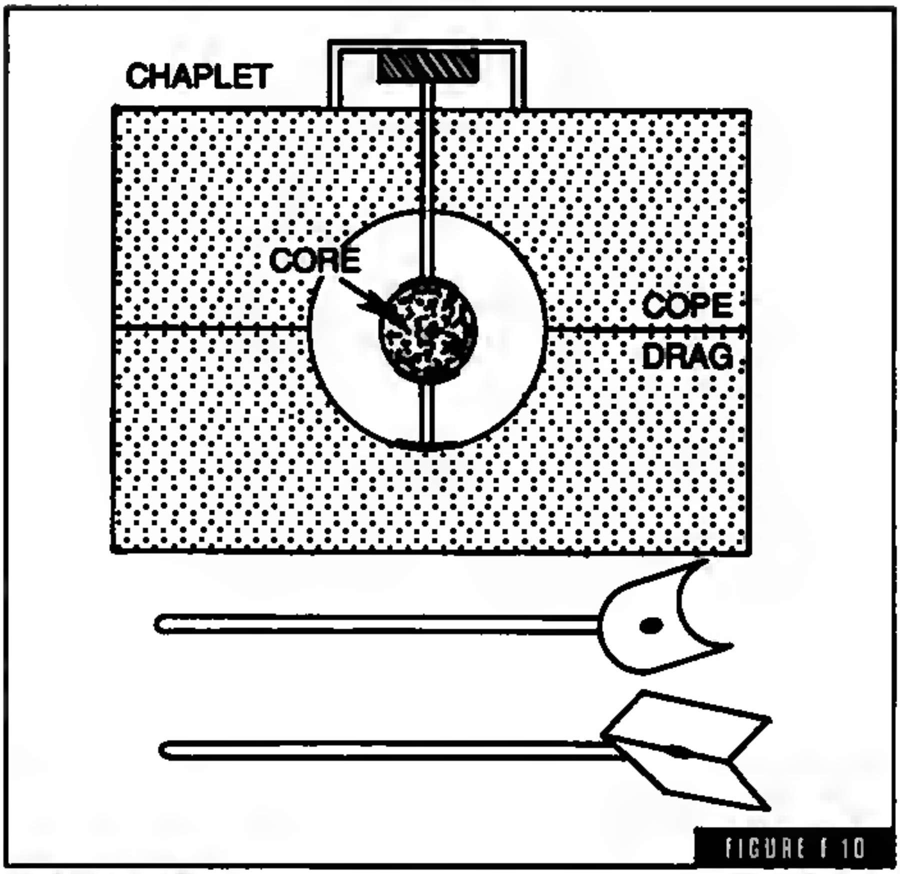


FIGURE F 10

Fitted head chaplet.

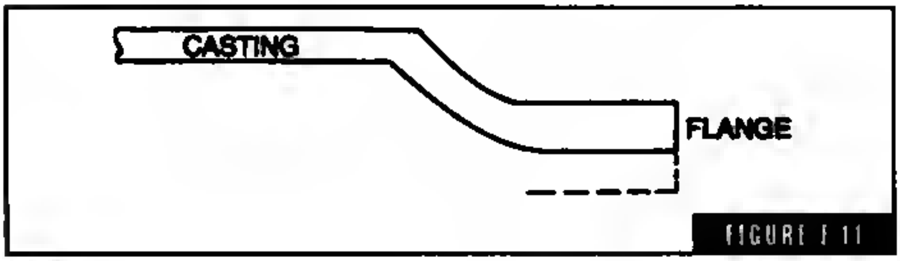


FIGURE F 11

Flange.

FIGURE F.12

Flat back patterns.

strength manganese will flare et about 1850 F. and high tensile Mg. Br. et or close to 1950 F.

flax swab Also called e *horse tail*, it is used to swab the sand around the pattern et the junction of pettern and sand (Fig. F-13). To prevent it from breaking ewey when the pettern is rapped and lifted from the sand, it is dampened by dlpping it into e pail of weter and shaking it out well. Used on floor work where the pettern presents e fair-sized perimeter.

The swab ls also used by some molders to epply wet mold wash or blacking to e mold surface. This requires greet dexterity.

flint shot Flint rock ground, crushed, and graded for use in plece of sand for sand blasting. Flint nodules look like pearls and are free from cleavage lines. It is hard and clean and outlasts sand 3 to 1.

floor flasks Flasks thet are too large to be handled on the bench (Fig. F-14). These can he of wood or metal. The wood flasks are constructed in such e manner thet the long sides provide the lifting handles for two man lifting and handling.

In floor flasks, unlike bench flasks, when you reach e size of 18 × 18 inches to 30 × 30 inches, members called *bars* are put in the cope. These bars help support the weight of the sand in the cope and prevent it from dropping out. Bars are required in the drag half of the flask only when it is necessary to roll the job over and lift the drag instead of the cope. In this case they are called *grids*.

FIGURE F 13

A flax swab.

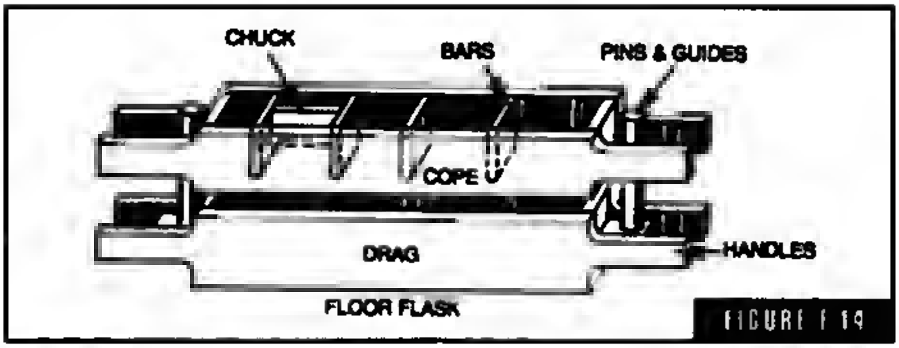


FIGURE F 19

Floor flask.

Tha bars do not coma all the way to the parting but clear tha parting and portion of tha pattern that is in tha copa by a minimum of ½ inch. These bars in many cases have to be contoured to conform with the portion of pattarn that is in tha cope.

In all cases tha bars are brought to a dull point along thair lower edga to make it possibla to tuck and ram the sand firmly under the bars.

Tha insida surfaces of both tha flask and the bars in the cope section are often covered with large-beaded roofing nails with the head projecting ½ to ¼ of an inch. This gives the entire inner surface an excellant tooth and a good purchasa on tha sand.

Of course tha floor flesk, like all others, must be provided with suitabla points and guides on both ands.

floor rammer Sama purpose and design as a bench rammer only tha butt and peen ends are mada of cast iron and attached to each end of a piece of pipa or a hickory handla. Tha averaga langth is 42 inches.

flowability The ability of e molding sand to flow and be easily rammed around e pattern. The ebility of a sand to pack in and around a pattern with a uniform density.

flow rate The relationship of pouring rete, height of eprue, area and diameter of tha sprua. For exampla, a round sprua ¾ inch in dl-ameter 5 inches tall will daliver 1 pound of moltan aluminum per second. A sprua tha sama size, only 15 inches tall will deliver 1¼ pounds per second. A 2-inch sprua 5 inches tall will daliver 5¼ inches per eecond, and at 15 inches tall, 2 inches in diameter it will deliver 10 pounds per second.

fluidity The ability of molten metal to flow readily, as measured by the length of a standard spiral casting.

flushing of metal Bubbling an inert gas through a metal bath with a metal or carbon lance to remove hydrogen, oxygen, etc., from the molten metal.

flux Applying a solid or gaseous material to molten metal in order to remove oxide dross and other materials. Sometimes referred to as refining.

flux inclusions Flux and/or slag poured down the sprue and winding up on or in the casting. Caused by improper ladle or crucible skimming, not choking, improper gates, or completely emptying a ladle or crucible during pouring.

fluorspar A commercial grade of calcium fluoride CaF_2 used as a flux in ferrous melting.

fly ash A finely divided product of combustion, sometimes found as inclusions in metal melted in an open hearth furnace.

foaming metal Manganese bronze and aluminum bronze have a tendency to foam like beer. This foam solidifies and appears as dross in or under the surface of the casting.

The least agitation in handling causes foaming. The metal must enter the mold quietly at the bottom and fill the mold by simple displacement.

follow board A board with a cavity or socket in it which conforms to the form of the pattern and defines the parting surface of the drag (Fig. F-15). It can be made of wood, plaster, or metal. When made of sand it is called a *dry sand match*.

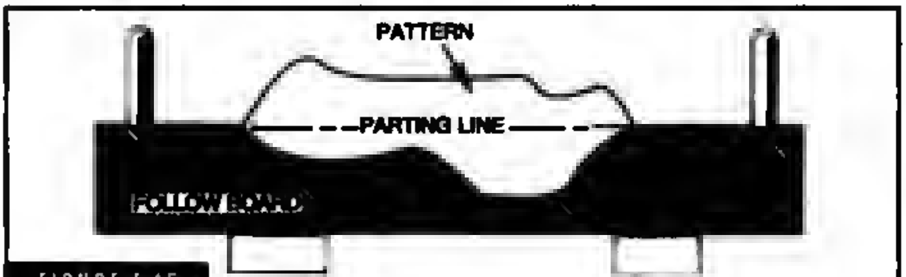


FIGURE F-15

Follow board.

The pattern rests in the follow board while making up the drag half of the mold and, in doing so, establishes the correct sand parting. The follow board is removed, leaving the pattern rammed in the drag up to the parting. The cope then takes the place of the follow board and is rammed in the usual manner. A simple follow board might consist of a molding board with a hole in it to allow the pattern to rest firmly on the board while the drag is rammed.

forehearth A refractory-lined reservoir in front of a cupola connected to the cupola by a trough. It is used to collect the metal from the cupola (Fig. F-16). The cupola runs continuously and the metal is tapped from the forehearth. It may be treated in the forehearth. A large quantity of metal can be accumulated in the forehearth for a large casting.

formaldehyde Also called *methylene oxide*. It is produced by the oxidation of methyl alcohol. Its composition is HCHO.

By condensing *urea* with formaldehyde you produce *urea-formaldehyde* resins, which are widely used in the foundry industry as binders for cores and shell molding (sand shell, not ceramic shell).

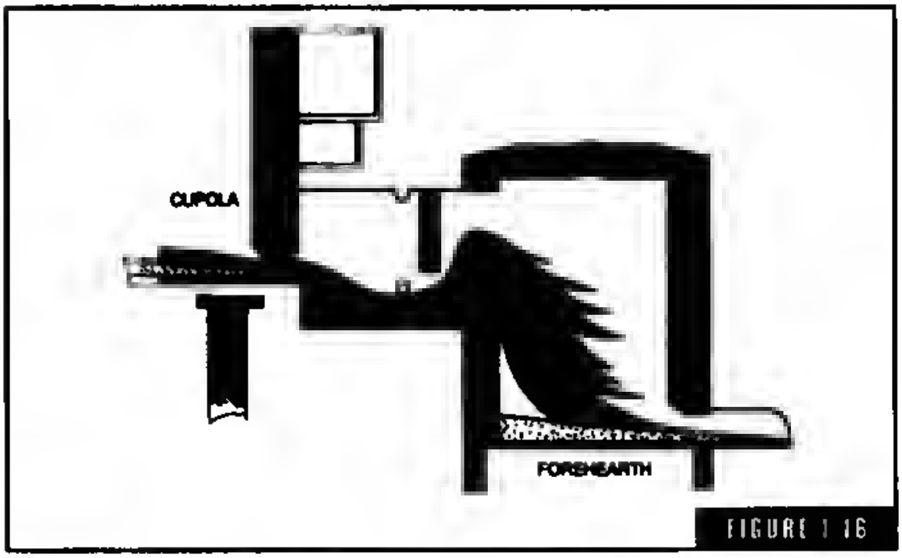


FIGURE F-16

Forehearth.

foundry An establishment or works where the production of castings is the principal endeavor.

foundry sprinklers Sprinkler cans used by molders to add moisture to molding sand to keep it in condition.

foundry torches Kerosene- or oil-fired torches used in the foundry for skin drying molds. They produce an easily controlled flame. Also used to dry small hand ladles which have been daubed.

freezing range of alloys This refers to the temperature range over which a given alloy freezes. In most cases the wider this range is the greater chance of segregation, a problem with some alloys. Silicon bronze solidifies over a range of 160 F., while copper 90 percent and tin 10 percent solidifies over a 300 F. range. With copper 90 percent and zinc 10 percent, the range of solidification is negligible.

freezing ratio

$$\frac{\dfrac{\text{Surface Area of the Casting}}{\text{Volume of the Casting}}}{\dfrac{\text{Surface Area of Riser}}{\text{Volume of the Riser}}}$$

If the two are equal, the freezing ratio is unity, and the riser and the casting will solidify at the same rate.

French gates The system of pouring flat plates on end rather than horizontally. The French gate is attached to the casting its entire length (Fig. F-17).

French rammer The French rammer is a piece of 1 inch diameter cold roll steel turned to an eye on one end and slightly tapered on the other (Fig. F-18). The bulk of the ramming is done with the eye.

French sand For many years French sand was considered the finest naturally bonded molding sand for fine art work, plaques, statuary, etc. Many of Rodin's pieces were cast in French sand. This sand comes from Fontenay des Roses near Paris. I have been told that they have been digging sand from this pit for some 400 plus years. It was common practice for many foundries to keep a ½ ton or more of French sand in the shop for that special job or a gravemarker casting. Use it as a facing, riddled against the pattern ¼-inch thick, then backed with regular or system sand.

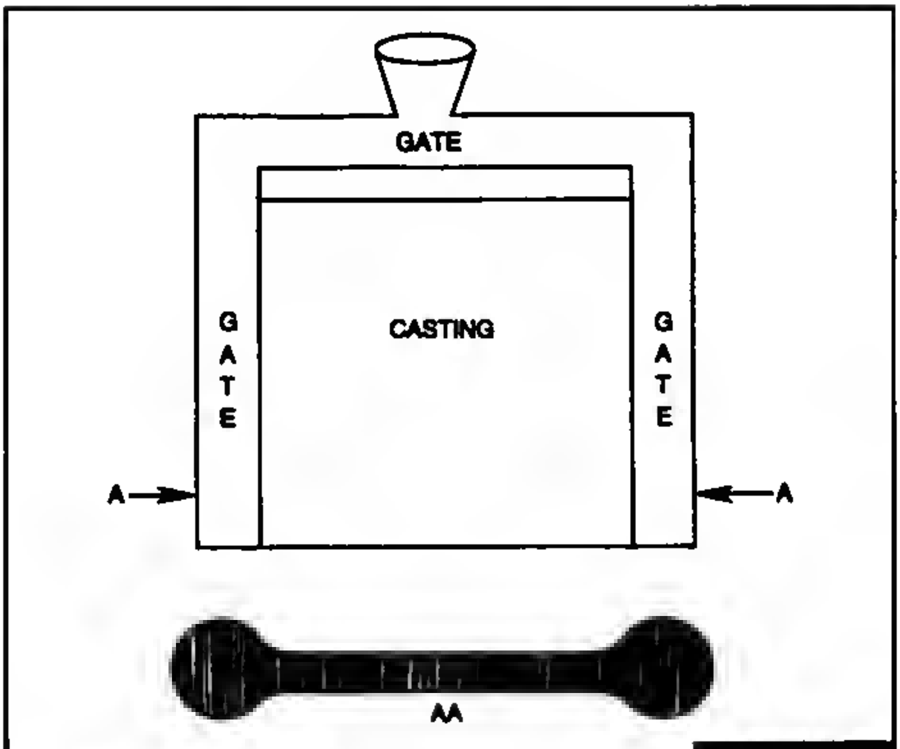


FIGURE F 17

French gates.

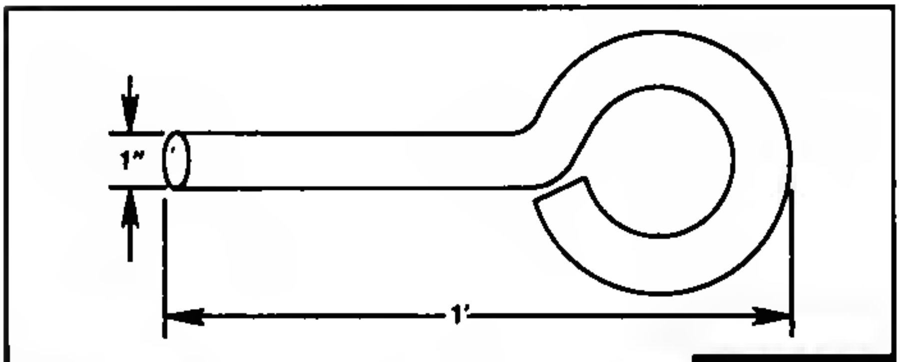


FIGURE F 18

French rammer.

Ten random samples of French sand showed the following test average:

- Clay, 17.2 percent
- Permeability, 18 at 7.2 percent moisture
- Grain fineness, 178
- Green strength, 10.5
- Shear, 3.1

Yankee sand, which replaced French sand during World War I, comes from around Albany, N.Y. An average of 10 samples showed:

- Clay, 19.8
- Permeability, 18.4 at 8.5 percent moisture
- Green compression, 16.7
- Shear, 3.8

fuels for melting Any fuel used to melt metal—solid, gaseous, liquid, or electrical, coal, coke, natural gas, oil, etc.

fuller's earth A clay closely related to bentonite. Has also been used as a sand binder.

full pattern A pattern that is constructed in one piece and not requiring that it be split in order to mold the job (Fig. F-19).

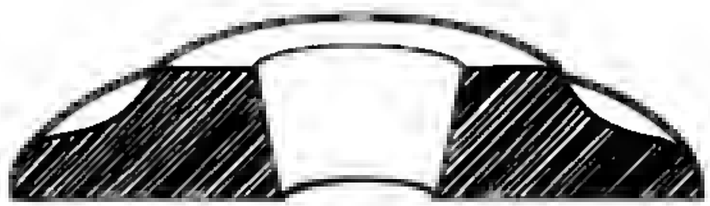


FIGURE F-19

Full pattern.

fuming bronze Flaring manganese bronze. It is believed by some that a few minutes of fuming, then replacing the lost zinc gives you higher tensile strength in the casting.This school is very much divided. Some say under no conditions flare the heat.

furans Various derivatives of furfural produced from formaldehyde and acetylene are known collectively as furans. They are used to produce resins and plastics. The furans most widely used in the foundry are furfural alcohol resins. These resins are the basic of the furan no-bake process of molding and core making, which has grown in leaps and bounds in the last several years because of the following advantages:

- Simple sand mix—resin, sand, and activator
- Excellent flowability
- Reduced rodding
- Reduction of skilled personnel
- Less core and mold finishing
- Uniform hardness
- Closer tolerance and smoother casting
- No ovens required, self curing
- Easy shake out
- Smaller molds due to its strength
- Cores and molds do not develop thermal cracks when poured
- Molds can be used for ferrous or nonferrous molding
- No flasks required
- Less weighting

The normal formula for furan no-bake system is 2 percent binder against the weight of the sand—100 pounds sand, 2 pounds furan binder. The activator or catalyst to set the binder is phosphoric acid (85 percent). The amount of binder required is 25 to 30 percent of the weight of tha binder. The average formula is 100 pounds sharp sand, 2 pounds binder, and ½-pound phosphoric acid (85 percent).

The activator is mixed with the dry sand, then the binder. The time the sand takes to set up is varied with the amount (percent) of activator used. Most pattern coatings are soluble in furfural alcohol. Heat is generated by the polymerization of the resin. You must use uncoated patterns, dry parting, or wipe the pattern or core box with kerosene and rub the surface with graphite or mica. (The kerosene parting system works best.) There are some commercial pattern coatings available for the no-bake system.

furnace, induction The induction furnace operates by the process of induction (Fig. F-20). The metal charge is made the secondary of a high frequency transformer, 1000 to 3000 cycles. Eddy currents are induced in the metal charge in much the same way a transformer introduces them in the secondary winding. The winding in this case (secondary) is the metal charge, which acts like a short circuited secondary.

furnace, passive A charcoal- or coal-fired nonferrous furnace which depends upon its blast air for combustion by the draft created by a chimney or stack (Fig. F-21). The fuel and crucible rest on a grate.

furnace, pit A furnace usually placed in a pit with the cover at floor level.

furnace, tilting A furnace which can be tipped in order to pour the molten metal bath into a receiving or pouring ladle by hand wheel, lever, hydraulic or air cylinders.

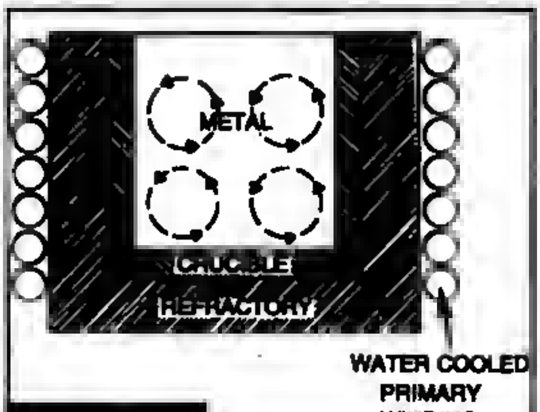
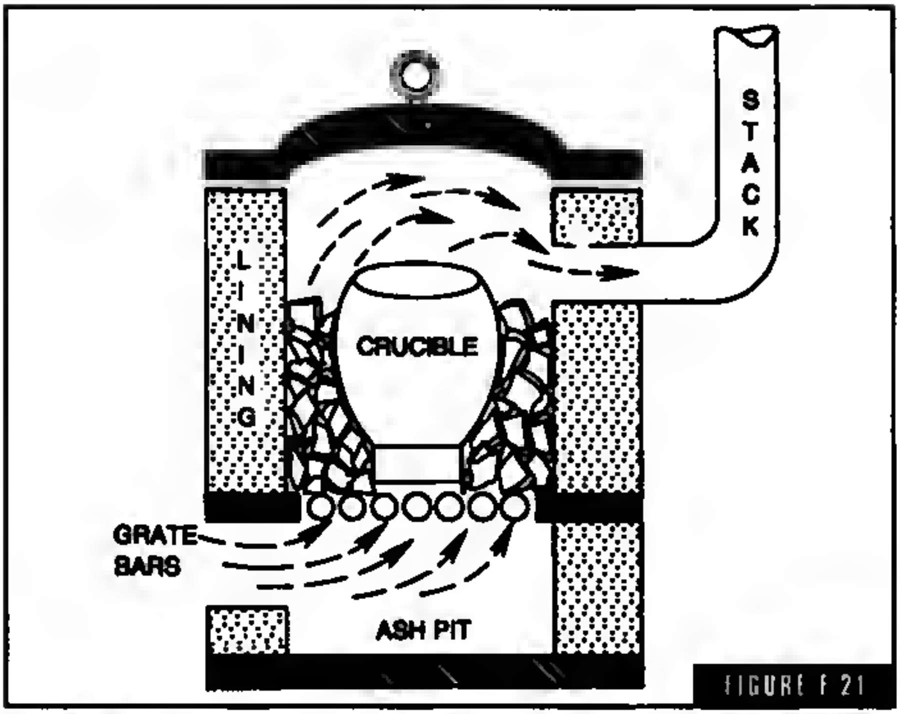


FIGURE F.20

An induction furnace.

fused silica Silica that has been fused at a high temperature and ground into various meshes (particle sizes). Used as a refractory and as a stucco for ceramic shell molds.

fusion This defect is a rough glassy surface of fused melted sand on the casting surface, either on the outside or on a cored surface. The cause is a too-low sintering or melting point of the sand or core. It is quite common when a small diameter core runs through an exceptionally heavy section of great heat which actually melts the core. This can also be caused by pouring hotter



A passive furnace.

than necessary for the sand or cores. A mold or core wash can prevent this in some cases but if the sintering point of your sand is too low for the class of work, you need e more refractory sand; zircon, etc.

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gaggers L-shaped metal rods, square or twisted, used to assist in the supporting of the sand in the cope of e floor or larger mold (Fig. G-1).

ganister A highly siliceous sand stone used as e refractory, particularly for furnace linings; crushed and sized, it is used as e grog in refractory cleys.

garnet paper Sandpaper covered with crushed garnets in plece of sand. A high grade sandpaper preferred by petternmakers because of its long life and superior sanding ability.

gas generated The gas genereted by e core or mold wben beeted by the molten metal.

gas porosity Widely dispersed bright round boles which appear on fractured and machined surfaces. It is caused by gasses being ebsorbed in the metal during melting. The gas is released during solidification of the casting. The cause is poor melting prectices (oxidizing conditions) and poor deoxidizing prectices.

gate cutter The best gate cutter is made from e section of e tobacco can (Fig. G-2).

To cut e gete or runner in green sand, the teb is beld between the thumb and first finger and the gate or runner is cut just as you would cut a groove or channel in wood with a gouge. The width is controlled by bending the cutters' sides in and out. The depth is controlled by the operetor.

gated matchplate A matchplete wbere the gates and runners are attached permanently to the plete and petterns (Fig. G-3). In e pressure cast matchplete, the getes, petterns, and runners are all one casting (unit).

gated pattern The gate is the channel or channels in a sand mold through which the molten metal enters the cavity left by the pettern (Fig. G-4). This channel can be made in two weys. One wey is by cutting

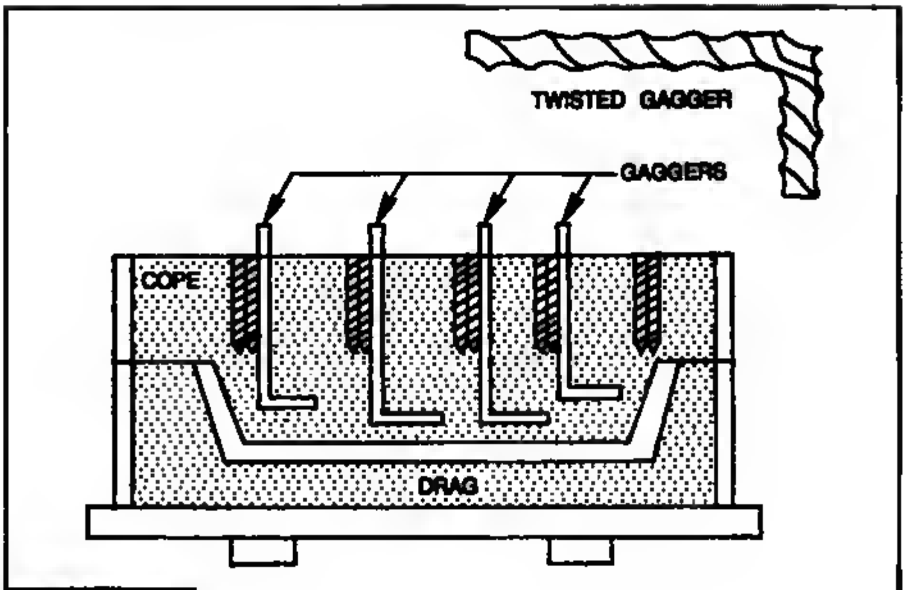

FIGURE G 1

Gaggers.

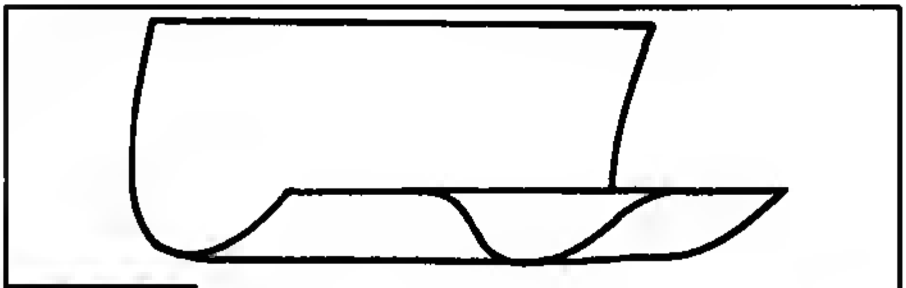

FIGURE G 2

Gate cutter.

tha channal or channels with a gata cutter. Tha other is by forming the pattern with a projaction attachad to it which will form this gata or gatas during tha process of ramming up the mold.

gates and risers Tha plumbing system usad to fill a mold cavity (Fig. G-5).

geared ladles Larga or small ladles equipped with a hand wheel and gearing mechanism, used to tip tha ladla.

Geneva chaplets A tin-plated sheet steel strong chaplet with e good bearing surface and unrestricted metal flow (Fig. G-6).

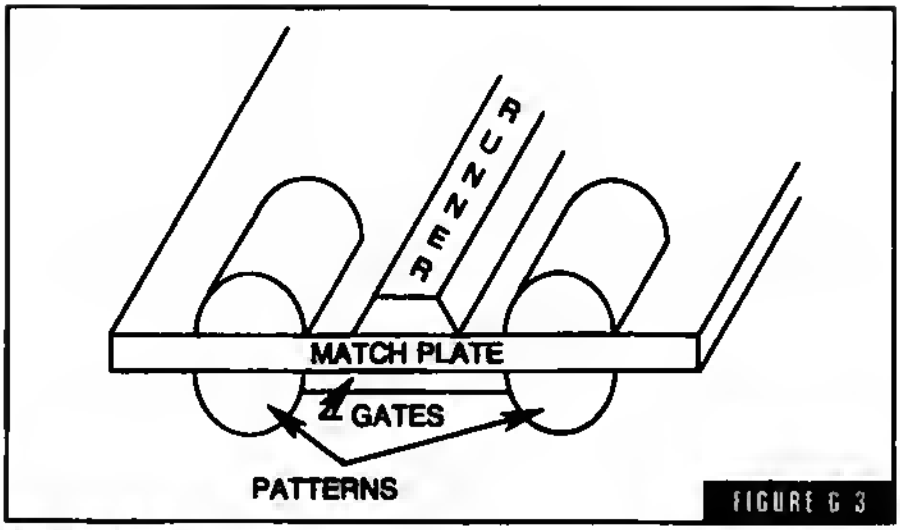

FIGURE G.3

Gated matchplate.

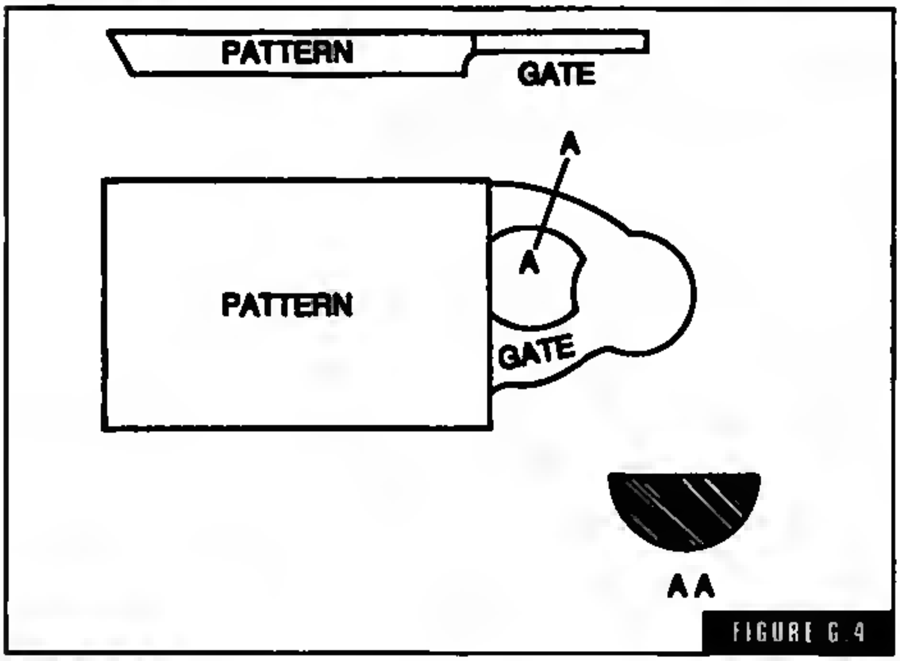

FIGURE G.4

Gated patterns.

German crucible clay A high grade clay used in the making of crucibles. It is sold bolted and used as a shake-on facing and a print back. See also *bolted cement.*

German silver A white alloy of copper, nickel, and zinc. The highest grade is extra white: 50 percent copper, 30 percent nickel, and 20

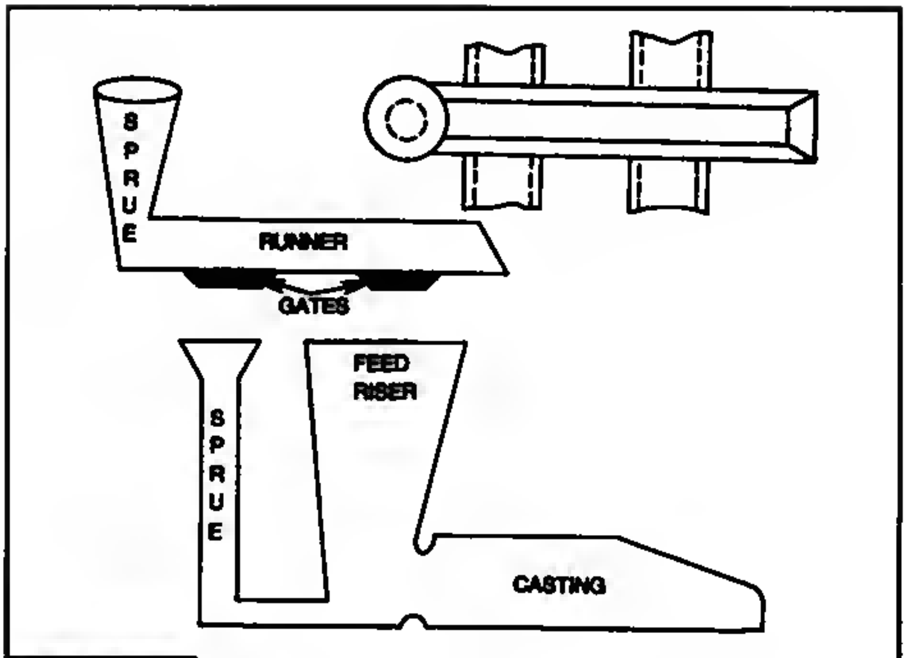

FIGURE G.5

Gates and riser.

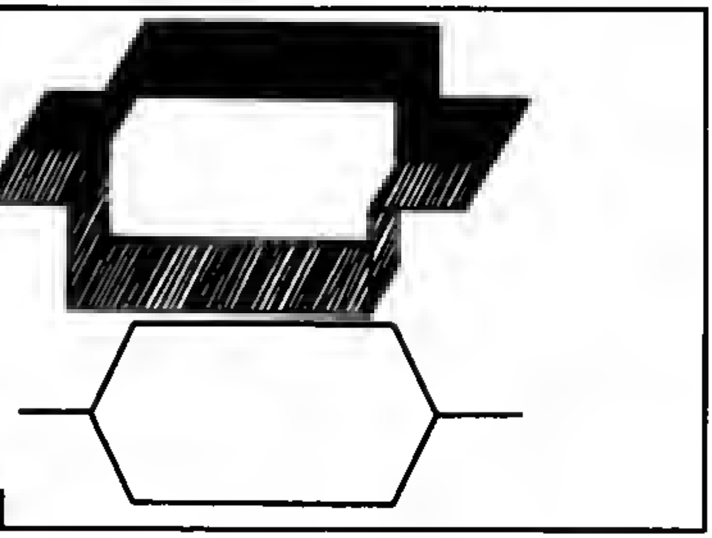

FIGURE G.6

Geneva chaplets.

percent zinc. The cheap grade, called *fifths*, has e yellowish color and is used where the finished part to be plated is 57 percent copper, 7 percent nickel, and 36 percent zinc.

germination The condition where you have abnormal grain growth. A few grains may grow et the expense of neighboring grains during solidification.

glue patternmakers Glue used to glue up stock and pattern members. Animal hide hot glue, cooked in e double boiler, was the standard for years. However, it has been repleced by various liquid glues in the past several years.

glutrin A lignin sulphite liquid core binder also used as e mold sprey and in washes, glues, and muds as binders, etc. When dried to e powder it is called *goulac*.

goulac A dry water soluble powder made from lignin sulphite liquor. It is e by-product of the paper pulp industry and used as e dry core binder in facing sand mixes. When mixed with water, it is used as e mold, core sprey, and wash binder, and in core pastes as dough rolls. It is e replacement for molasses in the foundry.

grab hook A grab hcok differs from e sling chain hook in shape (Fig. G-7). The opening is much wider so that it can be hcoked into the rollover ped eyes on large flasks. Also used to lift large copes.

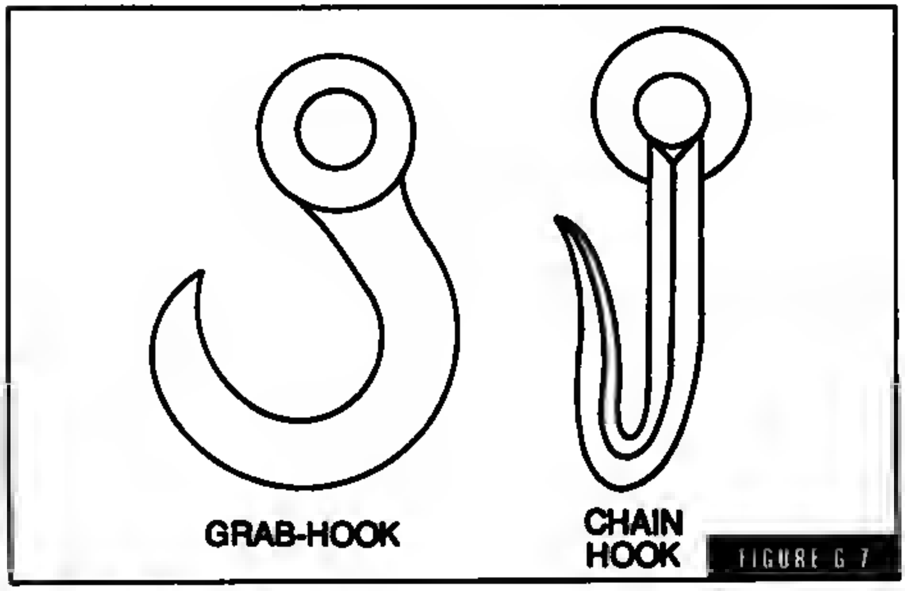

FIGURE G 7

A grab hook and chain hook.

graphite A crystalline or amorphous carbon used in the foundry as a mold coating and core wash. It is an additive to some molding sands and crucibles. It goes by many names including *blocking, plumbago, silver lead*, and *ceylon lead*. By whatever name used, it is a form of carbon which can differ greatly in its physical properties. The finest grain is a crystalline graphite from ceylon. The chief action, when used as a facing for a sand mold, is that it fills in the spaces between the sand grains and provides a smooth highly refractory surface upon which the metal can lie. This coating allows the sand to peel cleanly from the casting and prevents burning in—sand melting on to the casting surface. It is amorphous graphite when used for cast iron. A carbide iron surface is formed on the casting due to it being dissolved by the molten iron; this produces a dirty hard surface. When crystalline graphite is used, it is not dissolved and imparts a smooth easy-to-machine surface that is bluish in color.

A lead pencil is graphite (not lead). However, lead will make a mark very much like graphite when rubbed on paper. This is probably how graphite got one of its many names, *block lead*.

As a wet mold and core wash, it is combined with a suitable binder and sold under many trade names. Some companies put out graphite washes which contain graphite with a binder which you mix with a volatile liquid as a vehicle. Alcohol and naptha are the most common. These washes are sprayed or brushed on to a mold or core surface and then ignited. The vehicle burns and the resulting heat sets the binder to form a firm, baked on coating. When the vehicle is water with a water soluble binder such as lignin sulphite, the coated mold or core must be dried with a torch or in an oven to remove the water and set the wash. As a dry mold facing it can be used as is or with a small amount of wheat flour as a binder.

It is applied to the mold by shaking it on the mold cavity through a porous cloth bag (*blacking bag*) or brushed on with a fine camel hairbrush. The excess is blown out with the bellows.

It is also sold in graded flat plates or crystals used to form a cover on melting bronze to prevent oxidization. When the metal is melted, the plates float on the metal to form a shingle-like cover that prevents the products of combustion (burner) from coming in contact with the metal surface. They are skimmed

back to pour and used over and over. Graphite crucibles are made of German fire clay and graphite and fired in e kiln like pottery. Graphite can be purchased in many grades of fineness from air float to fairly coarse. Super fine collodial graphite is used as e coating for die cast dies and permanent molds (metal molds) by suspending it in water and spraying the hot die or cevity. The water evaporates, leaving e fine coat on the mold surface. It prevents the casting from sticking in the cavity or soldering itself to the cavity. This coat usually lasts for several castings. I have found over the years that anything short of the finest grade (most costly) is foolish finance.

The higher percentage of pure carbon the better; look for high carbon that is free from grit and foreign material. There are quite e few prepared graphite-based washes and facings on the market containing various synthetic and natural binders, edditives, and vehicles. They can be purchased dry (you mix it to suit yourself) or pre-mixed. One of the best all around commercial products I have found for both e mold and core wash is sold under the trade name of Zirc-O-Graph™ A. It is a paste-like form of graphite and zircon flour with e binder which you mix with isopropol alcohol to the desired *baume*—a measure of epecific gravity of liquids and solutions reduced to e simple scale of numbers.

Grephite can be produced artificially by passing an alternating current through e mixture of petroleum coke and coal tar pitch.

Each foundry supply manufacturer markets various types of washes and facings designed for molds, cores, ladle liners, etc.

graphite stopper The stopper attached to the stopper rod of a bottom pour ladle (Bessemer ladle). A stopper ettached to a rod used in a large reservoir used to pour a mold.

gravel Grevel refers to any granular material. An eppreciable portion would pass through a sieve with ¼-inch openings but be retained on a No. 6 eieve (eix openings per square inch).

green bond strength The strength of a tempered sand expressed by its ability to hold a mold in shape. Sand molds are subjected to compreseive, tensile, ehearing, and transverse stresees. Which of these stresses is more important to the sands' molding properties is e point of controversy.

The green compressive strength test is the most used test in the foundry. A rammed specimen of tempered molding sand is

produced that is 2 inches in diameter and 2 inches in height. The rammed sample is then subjected to a load which is gradually increased until the sample breaks. The point where the sample hreaks is taken as the green compression strength.

green compression The measure of compressive strength of e green sand sample—tenacity.

green permeability The measure of the ability to pass gasses through e sample of tempered molding sand.

green sand molds A mold composed of prepared molding sand in the moist or as mixed condition.

grid bars and grids Large flasks where the drag is rolled over and e bottom board would be cumbersome or impractical (Fig. G-8). The drag is fitted with cast iron or steel grids. The drag is rammed part wey, the grid holted in place and finished through the openings in the grid.

gyratory electric riddle This piece of equipment is inexpensive by comparison to all other mechanical sand conditioners evallable (Fig. G-9). The comh electric riddles have been manufactured for many, many years. I have one that was built in 1925 and it is still going strong. That company is still in business and e new one can be bought today. The comb riddle is simply an electric riddle or sifter which, by its gyratory ections, tempers and aerates the sand in one operation. The term *riddle* means to sift through e screen.

The operation of e comb riddle is simplicity itself. A one-sixth horsepower, low speed motor drives e shaft which is ettached to

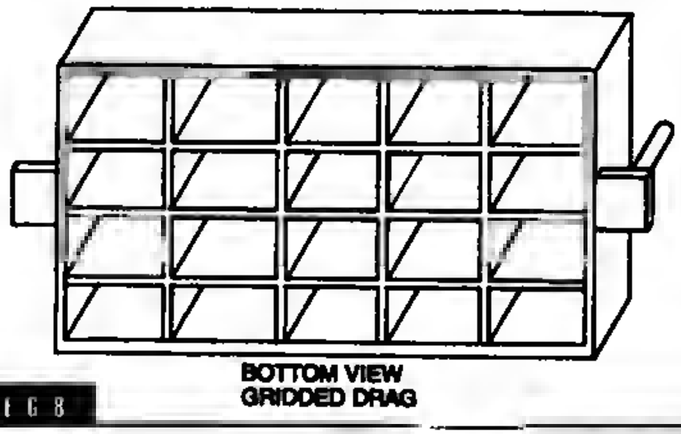

FIGURE G 8

Grid bars and grids.

e flywheel directly ehove the riddle. This flywheel is out of halance hy virtue of e lead weight attached to one side of the flywheel's inner rim. When the flywheel is rotated, it imparts e gyretory or shaking motion to the lower screen, ceusing the sand shoveled into the riddle to mix and go through. The screens are easily removed by e quick clamp arrangement for cleaning or changing. The screens can be purchased in e wide variety of openings from 8 to the inch to the ½ inch. The ¼ mesh or four squares per inch is most commonly used screen to condition sand.

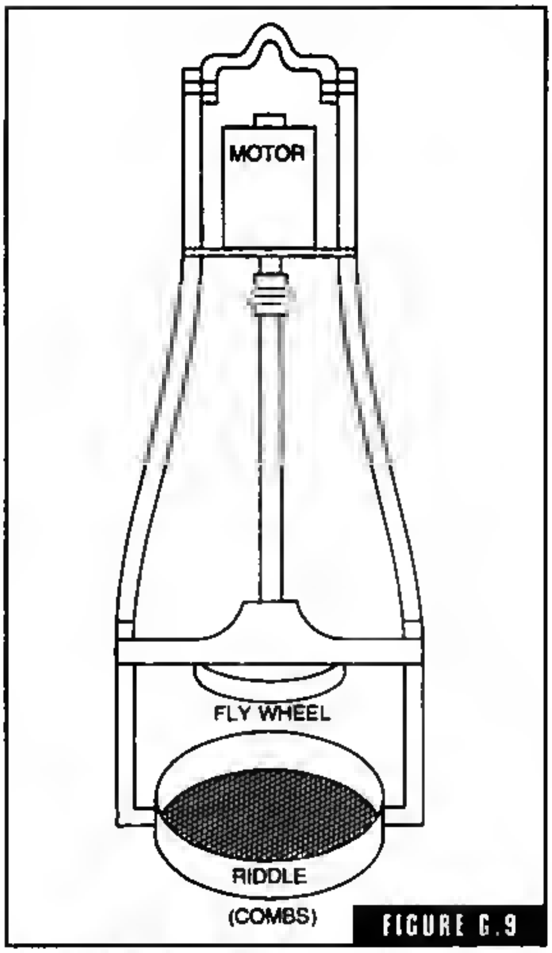

FIGURE G.9

Gyratory electric riddle.

H

hanging core A core which is hung from the cope hy tie wires (Fig. H-1).

hardener Any metallic or nonmetallic element added to a hase metal or alloy to increase its hardness. Antimony added to leed will increase its hardness.

hard spots A prohlem with metallic iron castings. Wherever thare is e shrink it will cause e hard spot and, es a result, machining difficulties.

hay rope A loosa rope mada of hey used to wind around core arhors. When making large loam or dry sand molds the rope provides e cushion to aid in the cora collapse and ample venting.

head strainer A strainer core (caramic or core sand) placad in a riser or heed when the casting is poured directly into the head (Fig. H-2).

heap sand The sand used in the foundry to produce the hulk of the work, also celled system or floor sand. Exclusive of special fecing sands.

heart trowel The heart trowel is e handy little trowel for general molding and, as its nama implies, hes a heart-sheped hlede. They run in siza from 2 inches wide to 3 inches wide in ¼-inch steps (Fig. H-3).

heat treating The physical properties of some metals such as hardness, ductility, and strength may he altered hy various methods of heating and cooling.

high lead tin bronze These elloys are treditionally the hearing and hushing hronzes. A typical high lead hronze would he 80 percent copper; 10 percent tin; 10 percent lead; .32 pounds per cuhic inch; pettern-makers' shrinkege, ⅛ inches per foot; pouring temperature light cestings 2,000 to 2250 F.; heevy cestings, 1850 to 2100 F.

high strength yellow brass Another name for manganese hronze. Typical composition: 63 percent copper; 25 parcent zinc; 3 percent iron; 6 percent eluminum; and 3 percent manganese.

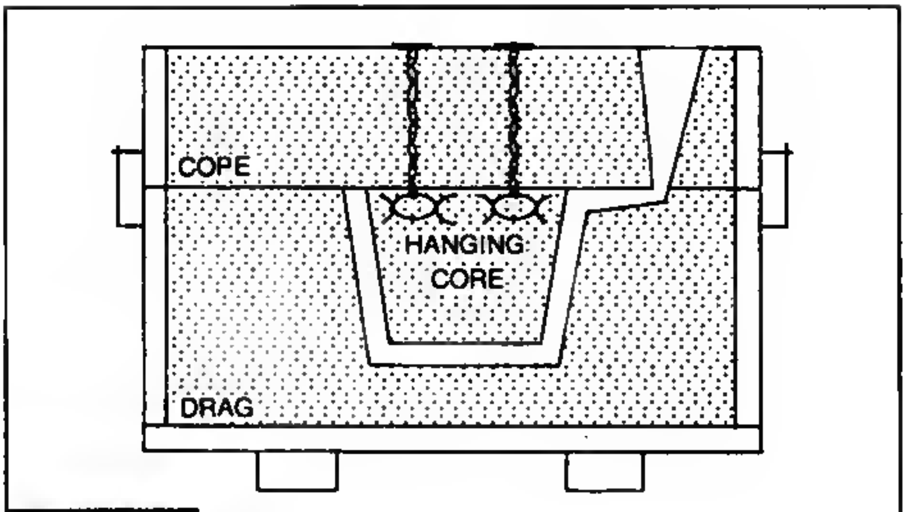

FIGURE H.1

Hanging core.

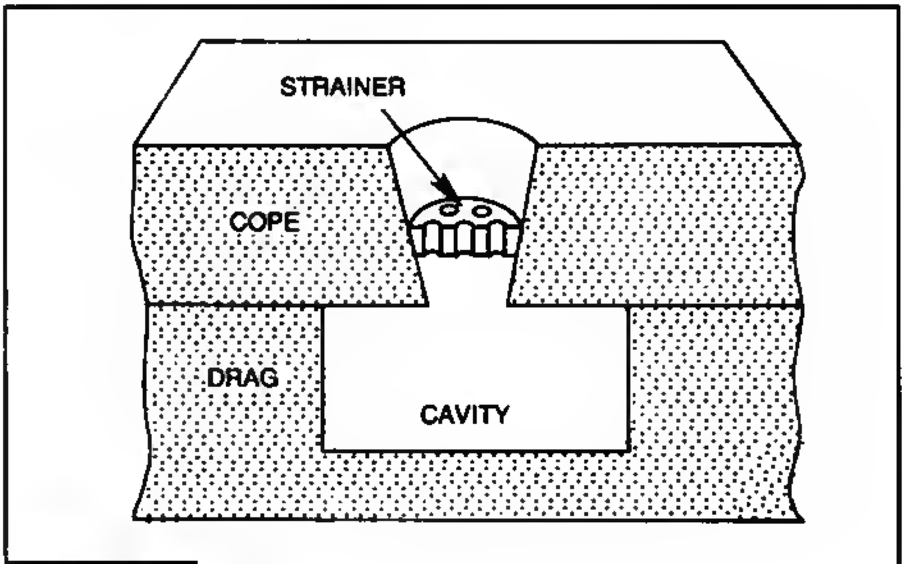

FIGURE H.2

Head strainer.

hinge tubes Tin forms used to core holes through ribs and lugs. They extend into the mold perpendicular to the parting (Fig. H-4). The hinge tube is placed in a properly fitted notch in the pattern before the sand is rammed. It remains in the mold after the pattern is drawn. Clean holes, accurate for size and location, are assured.

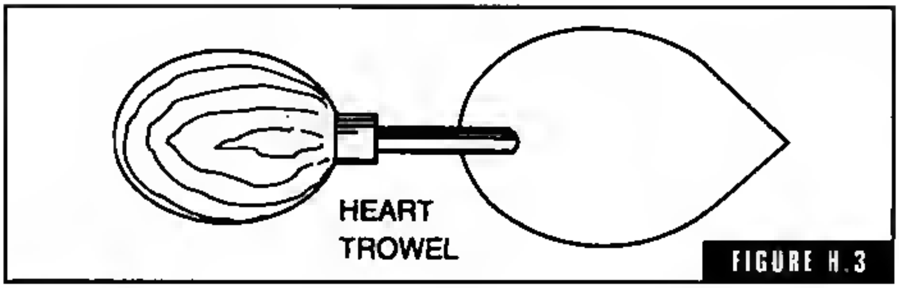

FIGURE H.3

Heart trowel.

Hinge tubes come in sizes from ¼ to 1 inch round and oval from $\frac{3}{16} \times \frac{5}{32}$ to $\frac{1}{2} \times \frac{3}{4}$ inches. They come ready to use with the pin tube filled with baked core sand.

holding furnace An electric or fuel fired furnece for mainteining molten metal from e larger furnece et the right casting tempera-

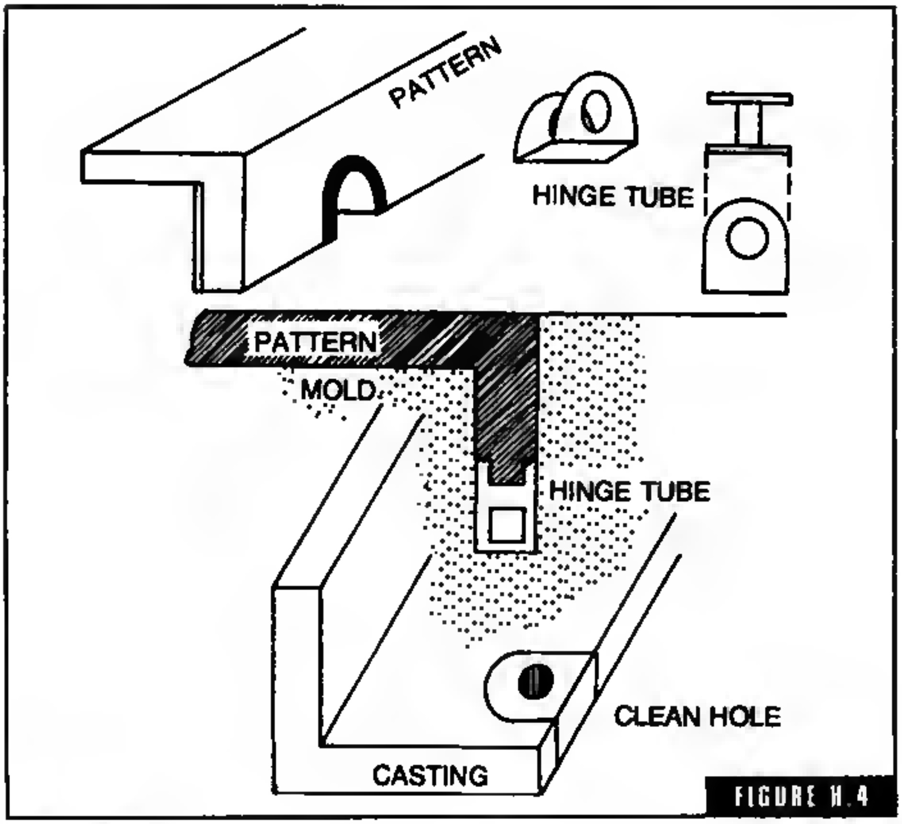

FIGURE H.4

Hinge tubes.

ture. The holding furnace is not a melting furnece and is ahle only to maintain the tempereture of e metal hath. It is used to collect and hold.

hot box process Accelerating the curing of a furan type hinder with heat. This is done hy ovens, infrared lamps, dielectric ovens, or by heating the core hox itself.

The application of heat greetly anhances the resin reection. Originally furan hinders were the same used in the no-hake system (cured at room tempereture). However, phenol hes greetly repleced or suhstituted all or part of the furfural alcohol. Phenol uree-formaldehyde or modified furan, phenol, furfural alcohol urea-formaldehyde are all used.

hot chamber die casting A die cesting mechine where the shot chamher is immersed under the casting metel and is self-filling. When the shot piston, on its return stroke, passes a port, the liquid metal fills the shot chamher through this port for the next shot.

hot spruing Removing castings from getes hefore the metal hes completely solidified. Hot spruing of light section cesting and intricate castings is widely precticed. The gates must be designed so that they will not hreak heck into the casting. Small and medium grey iron cesings can he cold sprued in most ceses, leeving only e nub to grind.

hot tears This defect is actuary a tear or separation fractura dua to the physical restriction of the mold and/or the cora upon the shrinking casting. Tha higgest ceuse is too high a hot strength of the core or molding sand. These defects can he externel or internel. A core that is overly reinforced with rods or an arbor will not collapse.

If you restrict the movement of the cesting during its shrinking from solidification to room tempereture, it will literary tear itself apart.

humectant Any material edded to foundry sand to retain moisture.

hydroblast Cleaning castings with e high pressure stream of weter and ehrasive (usually sand).

hydrogen Hydrogen is a colorless, odorless, tasteless elementary gas. It is aasily produced hy the disassociation of weter or from any hydrides.

hydrogen absorption The ebsorption of hydrogen by molten metal. The hydrogen usually comes from the products of comhustion crack-

ing hydrides as weter vapor H_2O. Some metals heve a greet affinity for hydrogen when heeted, aluminum in particular. Care must he exercised when melting with gaseous fuels so thet the flame is properly controlled. With eluminum it should be neutral or slightly oxidizing.

hydrometer An instrument used to check the *baume*, the specific grevity of liquids (Fig. H-5).

hypereutectoid steel Steel containing more than the eutectoid percentege of carbon.

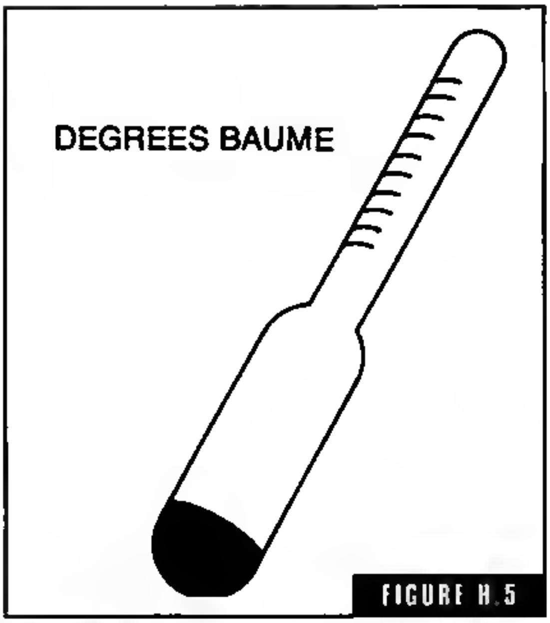

FIGURE H.5

Hydrometer.

I

infrared heat The use of infrared beat to bake cores with weter soluble binders and those thet soften on beeting and harden on cooling (such es rosin).

illites A type of bonding cley. Not ell illite cleys are suiteble but those with bigh bonding power beve good dispersion and are quite setisfectory.

impact test The test given to e meteriel with e pendulum in which the specimen is supported et one end as e cantilever beam (Fig. I-1). Meesures the energy required to break off the free end. Called *Izod test.*

impoverishment The loss of any constituent from an alloy or localized area of an elloy by oxidation, liquidation, voletilizetion, or changes in the solid state. Also celled *depletion.*

inclusions Dirt, sleg, etc. This defect is caused by failure to maintein e choke when pouring, dirty molding, failure to blow out mold properly prior to closing, sloppy core setting ceusing edges of the print in the mold to break ewey and fell into the mold. The drag sbould be blown out, the cores set, and blown out egain. Dirt falling down the sprue prior to the mold being poured or knocked in during the weigbting and jecketing are also ceuses.

inconel A bigh nickel metal used for furnece fixtures, dairy, and food equipment. 79.5 percent nickel, 13 percent chromium, 6.5 percent iron, 0.08 carbon, developed by Internetional Nickel Co.

in gates Tbe gete leading directly into the mold cavity.

inhibitor A meterial such as fluoride, boric ecid, or sulphur edded to the molding sand for cesting megnesium alloys to prevent burning of the molten megnesium. Restraining an undesirable chemical ection i.e., oxidetion. Any eddition to e solution or substance to prevent or minimize corrosion.

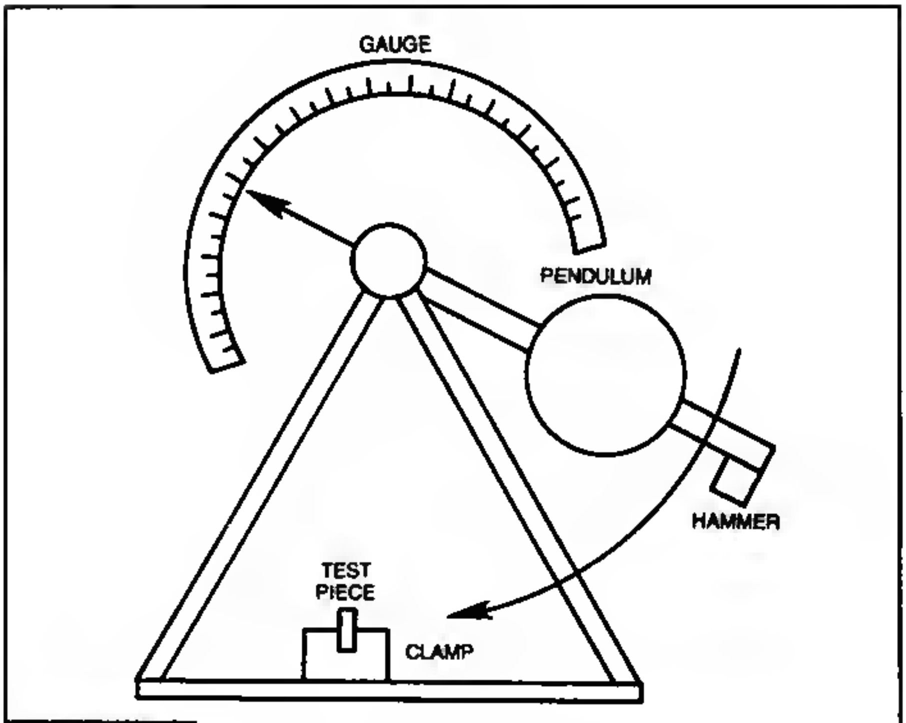

FIGURE I.1

Impact test.

Ingot molds Cest iron or steal molds for casting ingots; also usad to pig or ingot tha metal left over in a ledle or the day's melt.

Innoculant Any meterial edded to e molten metal which will modify the structure and change the physical and mechanical properties.

Irregular draw A pettern or portion of e pettern so constructad that it must be removed from the mold in other than e straight vertical lift (Fig. I-2).

Irregular parting A parting plane between the cope and drag that lies on more than one plane (Fig. I-3).

Inserts Parts formed of e second material, usually a metal. They are pleced in e mold and cest into the body of the casting and appear as integral structural parts of the final casting (Fig. I-4).

Inverse chill A defect found in grey iron castings. It is hard or chilled iron. The ceuse mey be incorrect carbon aquivalant for the job or the presence of nonferrous metals in the charge, like lead, antimony, or tellurium. They are detrimental impurities.

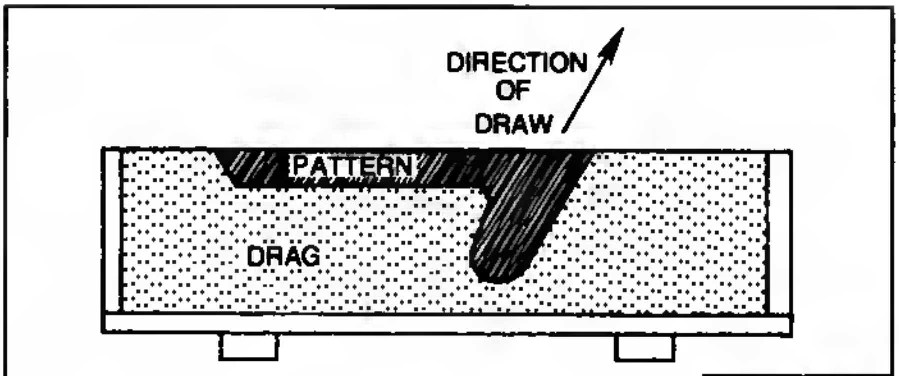

FIGURE I.2

An irregular draw.

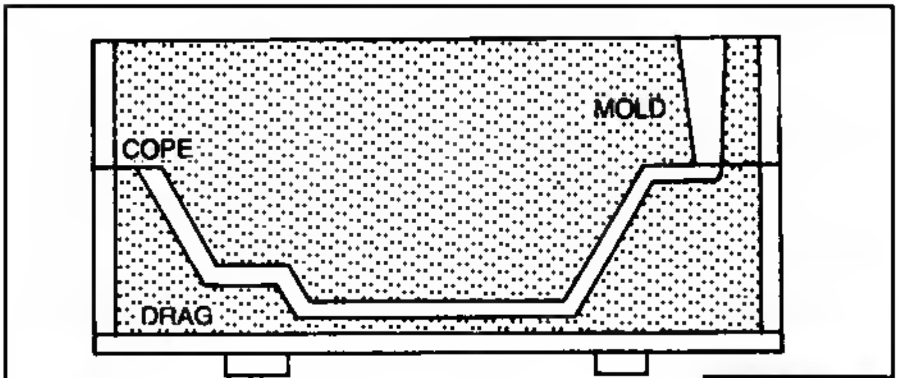

FIGURE I.3

Irregular parting.

investment casting wax Any wax used for expendable wax patterns and gates. It runs from a hard carving wax to extremely soft. Over 2,000 formulas are available in natural or synthetic waxes.

investment molds Molds constructed of a refractory material around wax or other expendable patterns such as plastic, mercury, etc.

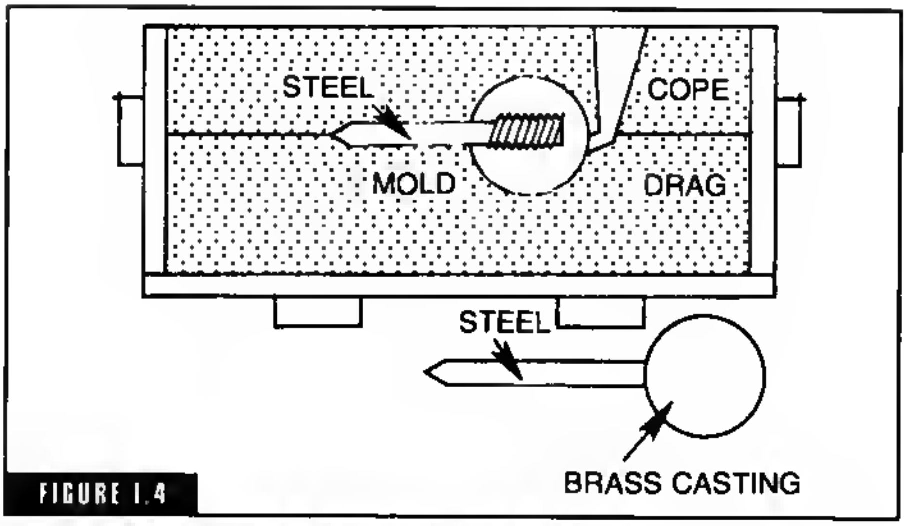

FIGURE I.4

Inserts appears as integral structural parts of the final casting.

J

jacket A wood or metal frame placed around e mold made in a snap flask during pouring to support the mold and to prevent e run out between the cope and drag.

The common practica is to heva as many jackets (for each size snap mold) es can be poured et one time. When the molds heve solidified sufficiently the jeckets are removed and pleced on the next set of molds to be poured. It is celled *jumping jackets.* Jackets must be carefully pleced on the molds so es not to shift the cope and dreg. The jeckets must be kept in good sbepe and fit the molds like a glove. A tepered snap flask and tapered jeckets work bast dua to tha teper.

jack stars Jack stars are wbite cast iron stars similar to the jecks cbildren play, axcapt that they ara pointed (Fig. J-1). These stars come in various numbars of points and sizes and are used to clean cestings in e tumbler. Tbe castings and stars are cbarged into the tumblar and the tumbler is rotated. Tha rotation causes the stars to rub and claan tha castings. The points of the stars pick and rub sand loose from the cestings. Tbey can be purcbesad, but most iron foundries heve e metcbplete of star petterns and cest them as needed.

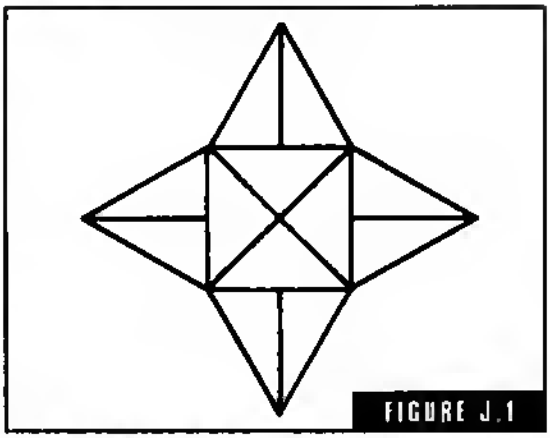

FIGURE J.1

A white iron jack star.

jar ramming Also called *jolt* romming. The pecking or ramming of the sand in a mold or core box by raising and dropping upon an anvil, the sand itself being the ramming medium (Fig. J-2). Jolt mechines come in various sizes

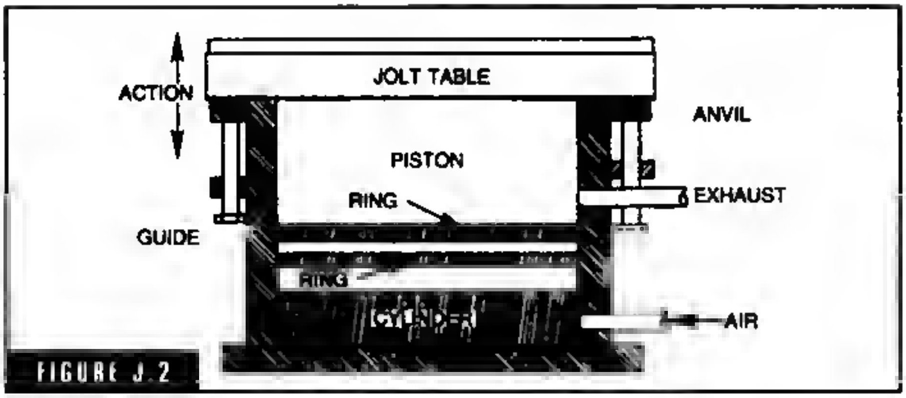

FIGURE J.2

The process of jar ramming.

from small bench jolt macbines to large mechines thet will handle an extremely large burden (weight). These mechines are pneumetic in operetion. The air enters the cylinder under the piston, raising the table and mold wben the piston passes the exbeust port. The air behind the piston exhausts, and the teble and mold fall, striking the anvil.

The ebrupt stopping of the table, mold, and sand upon striking the anvil does the ramming es the sand thet is free to move continues its trip downward. The cycle is repeated until the desired density of the ram is reached.

Jolt machines can he purchased with various features which roll the mold over and drew the pettern when the jolting is finished.

jet engine bronze An alloy of 68 to 62 percent nickel, 21 to 24 percent molyhdenum, 7 to 8.2 percent aluminum (less than .1 percent carbon, .25 percent silicon, .15 percent iron, and .30 percent manganese). This alloy is called *kinsalloy* and is used for bightemperature jet engine parts.

job shop A foundry which engages in casting for ell comers, as opposed to the captive sbop that manufactures numerous types of cestings in small quantities.

jolt pin lift machines Opereted by the same principal as the stripper. The foundrymen lift the rammed flask from the pettern. Tbe only difference is that it is done hy four pins engaging the four corners of the flask. Tbe pins are carried on a yoke, which is lifted by suitehle cylinders.

jolt squeeze pin lift machine A jolt squeeze machine equipped with a pin lift to draw the mold from the pattern which is fixed to the table.

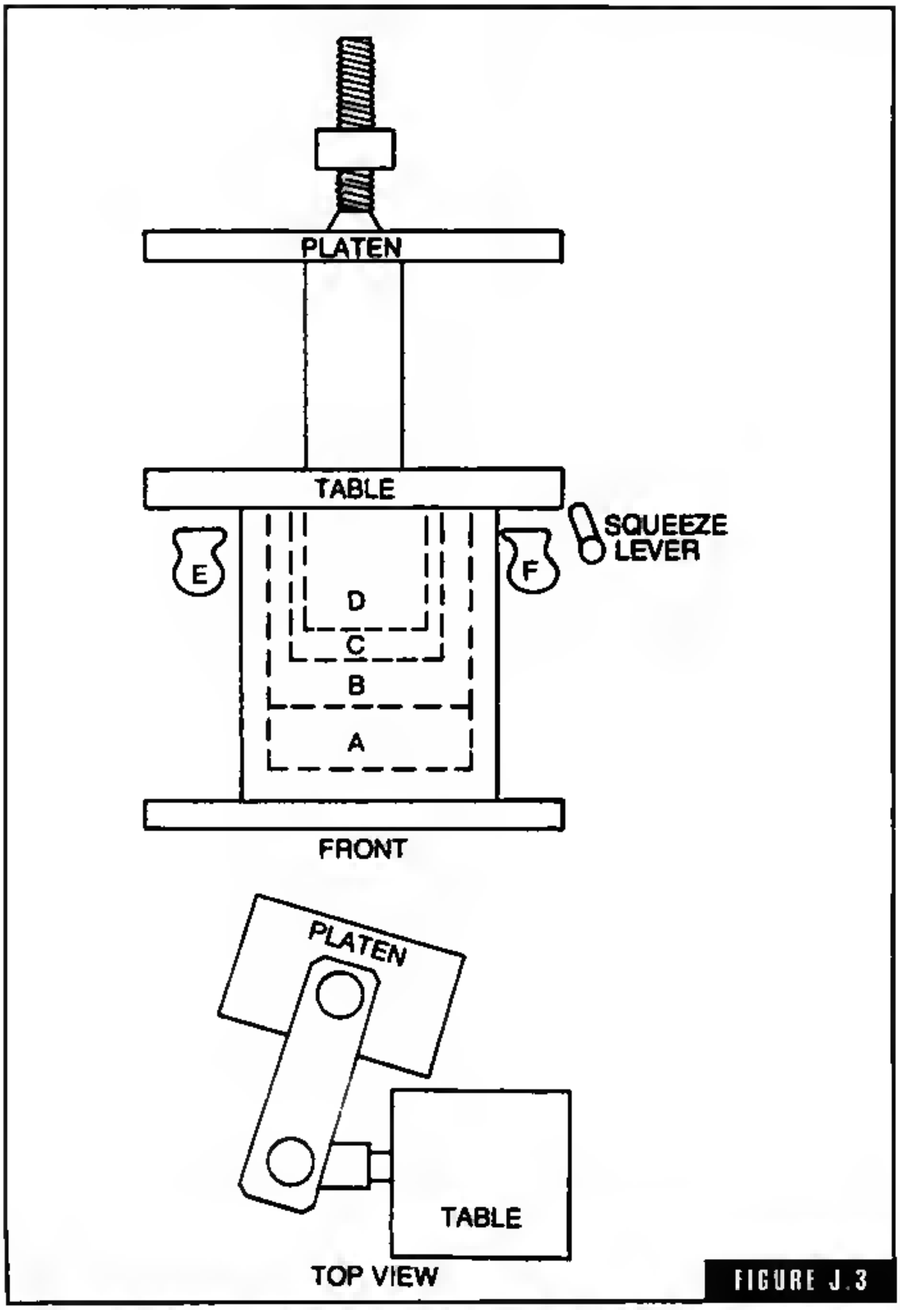

FIGURE J.3

A jolt squeeze molding machine. A. squeeze cylinder; B. squeeze piston; C. jolt piston; E. vibrator knee valve; and F. jolt knee valve.

Unlike the jolt squeeze machine on which the entire mold is produced (cope and drag), the jolt squeeze pin lift, jolt stripper, jolt rollover, jolt rollover and draw, and tha jolt pin lift machines produce half molds. The molders work in pairs. One operator makes drags and one makes the matching copes.

The usual comhination is a jolt rollover draw or jolt squeeze rollover, a draw machine for the drag (which must be rolled over), and a jolt pin lift or jolt squeeze pin lift for the cope.

Completely mechanized machines can he had to make the mold completely ready to pour.

jolt squeeze molding machine A molding machine which is equipped with two cylinders and two positions—one for jolting the mold and one for squeezing the mold (Fig. J-3).

The machina is equipped with a molding tahle and a movahle squeeze plate. The machine is designed to produce molds from matchplates. In operation, with the platen swung aside, the flask—complete with pattern hetween cope and drag—is placed on the tahle, drag side up. Sand is riddled onto the pattern, the drag is filled with molding sand, and a bottom hoard is placed inside the drag. The mold is jolted (see *jor romming*) hy the molder operating the jar air valve with his knee. When jolted sufficiently, the mold is rolled over with the cope upward. Sand is riddled on

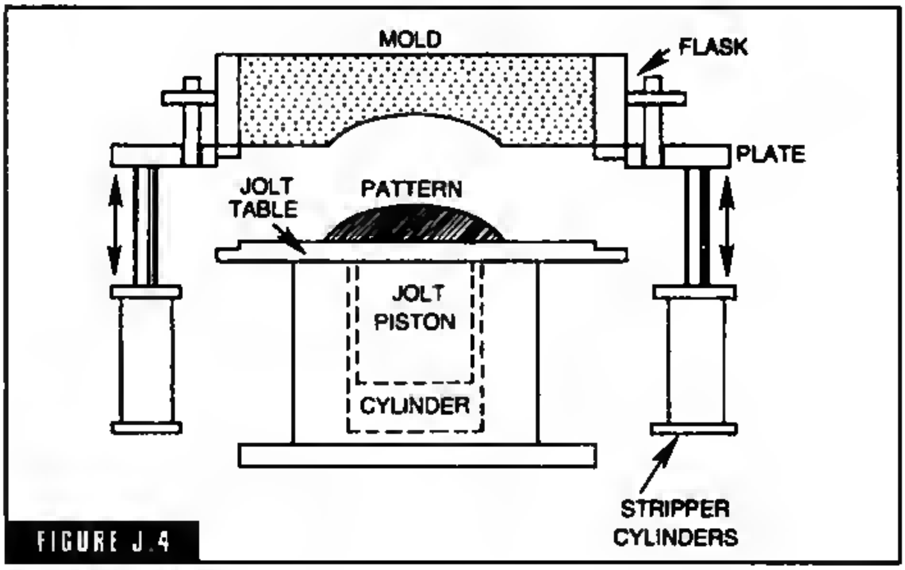

FIGURE J.4

Jolt stripper machine.

the petterns in the cope, the cope filled and peen rammed, and e squeezer board is pleced inside the cope. The pleten is swung into position and the squeeze cylinder ectueted. This procedure raises the mold against the platen and squeezes the entire mold between the bottom board and squeezer board, finishing the ramming of the cope and drag. The platen is swung aside the squeezer board, removed, and the sprue is cut. Tbe pettern is vibrated, the cope drawn and set off. The pettern (metchplete) is egain vibrated and drawn from the drag. The cope is then pleced on the drag and the completed mold is set off for pouring.

jolt stripper machine See *jar ramming*. Tbe jolt stripper machine is a jolt mechine with an air-operated lifting plete on wbicb the flesk bearing sets (Fig. J-4). This plete is raised drawing the mold balf from the pettern, whicb is fixed to the jolt table.

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K

kaolinite A hydrated aluminum-silicate clay also known as *fire cloy*. It is one of a family of three distinct minerals having a similar composition—kaolinite, nacrite, and dicite. It is e sedimentary clay of low flux content. Its prime use in molding sands is in facing for very heavy work and also in dry sand work when excellent hot strength is required. It is often hlended with western hentonite for this purpose. It comes closer than any other type of honding cley to producing a sand which approximates the properties of naturally bonded sands. It's tough, durahle, and eesy to use.

killed steel Steel that has heen completely deoxidized with silicon or aluminum to reduce the oxygen content to e minimum.

kiln dried The artificial air drying of pattern lumher in place of drying naturally.

kish (cast iron) If the carhon equivalent of the iron is too high for the section poured and its cooling rate is slow, free grephite will form on the cope surface in hlack shiny flakes free from the casting. It causes rough, holey defects, usually widespread. The carhon equivalent is the reletionship of tha total carbon to tha silicon and phosphorous content of the iron. It is controlled hy the make-up charge. Silicon is added et tha spout. It is called carhon equivalent hecausa the addition of silicon or phosphorous is only one third es effective es carbon, therefore the carbon equivalent of the three additives is equal to the total percentage of pure carhon plus one third the percentage of the silicon and phosphorous combined. The carbon equivalent is varied hy the foundryman depending on what type of iron he is producing and what he is pouring.

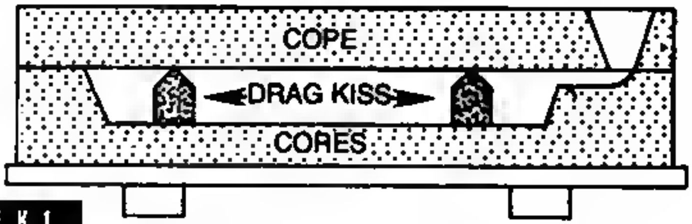

FIGURE K.1

A kiss core does not set in a print.

kiss core Kiss core is a small core which does not set in a print, but is held in place by the pressure of the cope surface of the mold (Fig. K-1).

knock out The operation of removing sand cores from a casting.

L

ladle additions See innoculant.

ladle bowls Hand sbank bowls wbicb are sbaped more lika a bowl than a hucket (Fig. L-1).

ladle shanks Tbe device by wbich a ladle is carried for transporting and pouring.

ladles Steel, refractory-lined containers usad to recaiva and pour molten metal. They range in size from small hand ladles to crane ladles of 100 tons and over in capacity.

lagging of patterns Increasing the size and dimension of a pattern by applying strips of wood, plastic, or sbeet wax to the area you wisb to increase in dimension.

lake sand Another name for river sand, sharp sand, hank sand, white sand, core sand, and sugar sand. Usually dafined as clay-frea high silica sand.

lamp black A practically pure carbon (soot) produced by burning carhonaceous substances in an insufficiant supply of air (reducing atmosphara). It is usad in core and mold washes and blackings.

large skim gates Skimmer tins (Fig. L-2). Round and perforated tins or mica used as a skimmer under the pouring basin or elsewhere in the gating system.

latent heat of fusion Wben a molten mass of pure metal starts to cool the temperature drops at a definite ratio. A point of solidification is reached wbere the temperature remains constant until the entire mass is solidified. Tbis point is called the *lotent heat of fusion*.

lathe dog A forged or cast L-sbaped device used to drive work in the lathe wben turning between centers (Fig. L-3). Tbe work is clamped in the dog jaw with a set screw or cap screws. The drive leg fits loosely into a slot in the faceplate.

launder An old term used to designate a channel for conducting molten metal.

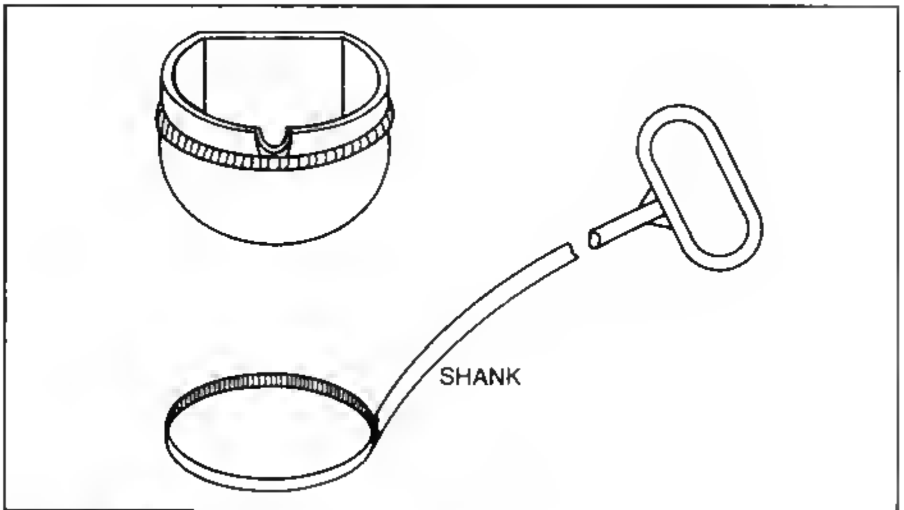

FIGURE L.1

Ladle bowl.

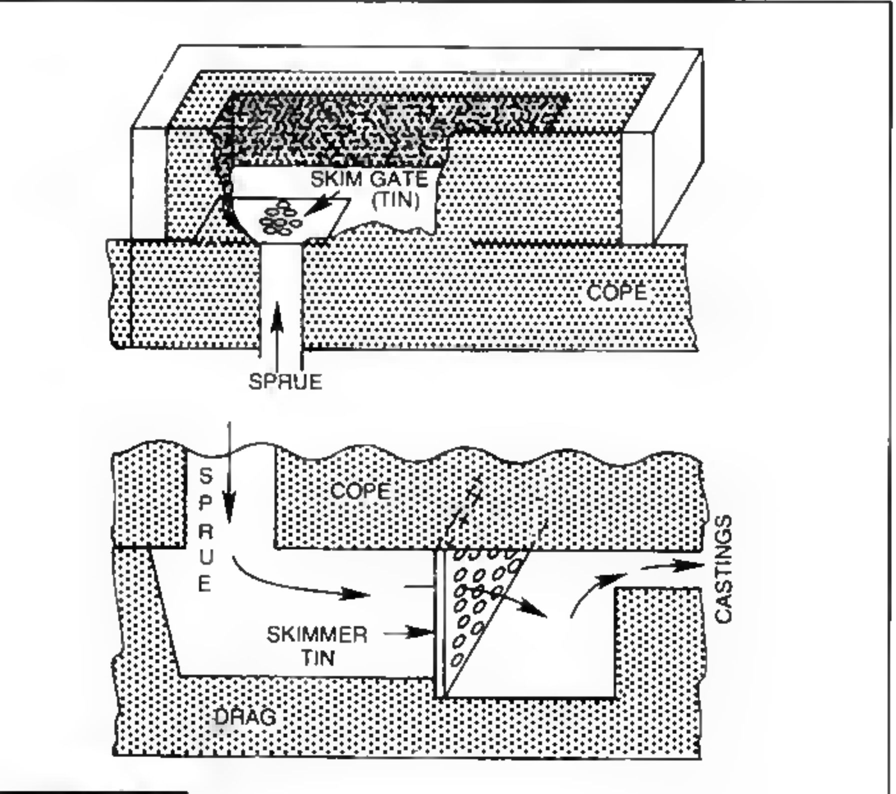

FIGURE L.2

Large skin gates.

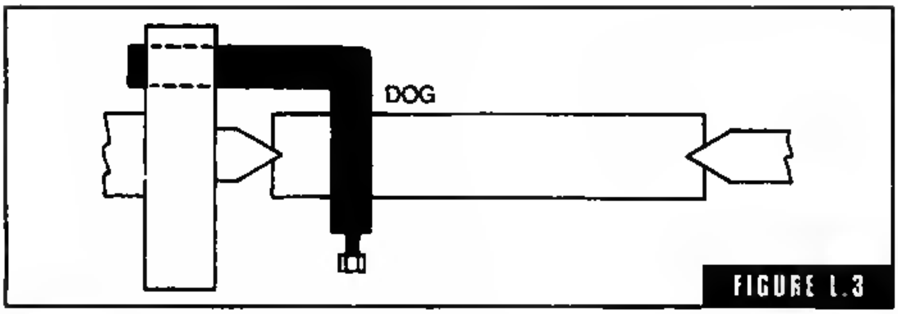

FIGURE L.3

Lathe dog.

layout board A smooth board with two sides square upon wbich the pattern layout is made. Tha dimensions are taken from this layout when making the pattern. A blueprint is used only to make the leyout beceuse they never sbow core prints, core boxes, etc., which tha patternmaker must determina himself and put on the layout board.

lead A soft heavy bluish metal, Ph, obtained chiefly from the mineral gelena. Melting point 621 F., boiling point 2777 F. When remeltad from scrap, it is celled secondary laad. It is widely used in alloying with other metals.

leaded cores A cousin of boltad cores (Fig. L-4). In plece of bolting e core together you can lead them together by pouring molten leed into the attachment holes and then covering the top counter sink with e cep core. The cores must fit very closely to prevent leed from running out et the joint.

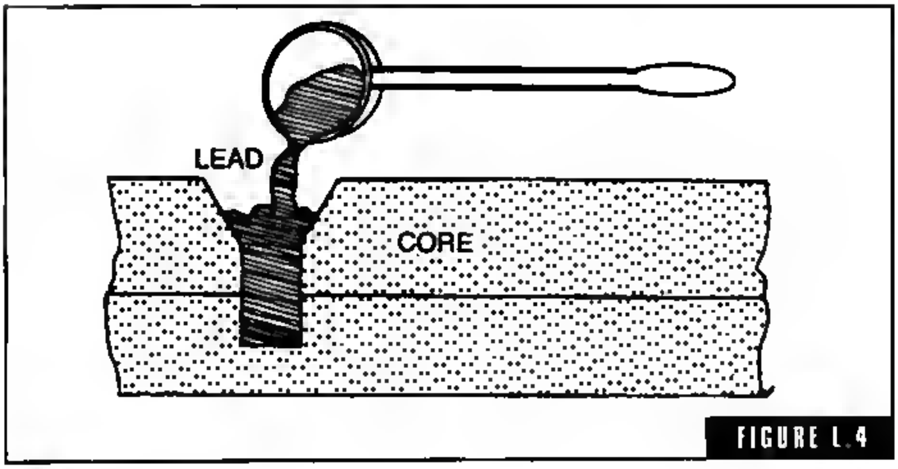

FIGURE L.4

Leaded cores.

lead dispersement The amount of lead that will go into solution with another metal. For example, pure molten copper will dissolve approximately 35 percent laad. If 2½ percent nickel is added, it jumps up to 70 percent.

lead effect The effect of lead as a defect. The presance of lead in a heat of aluminum bronze can cause a defect called *blue.* Tbese are blue to purple stains on the surface of the casting, usually from cores or chills as little as .005 to .01 percent of lead amounts. Over .03 will cause gray to black stains.

It has little effect in regard to physical properties other than to contribute to bot shortness at elevated temperatures. Lead in the amount of .40 percent and above in manganese bronze (high strength yellow brass) bas a deleterious effect on the mechanical properties and should be kept to .20 percent or lower. Lead in silicon bronze combines with the silicon to form lead silicate (glass). The problem is in distinguisbing some red brasses (leaded) from silicon bronze. A small chunk of a leaded red brass in a silicon bronze heat will spoil tha antira heat.

leaded nickel brass An alloy of copper, tin, laad, nickal, zinc, and iron. Also called nickel silver. When the alloy contains from 11 to 17.5 percent nickel in its composition it is called *leoded nickel bross.* When the nickel content is from 19.5 percent to 27 percent, it is called *leoded nickel bronze.*

Leaded nickel brass—typical:

- Copper, 58 percent
- Tin, 3 percent
- Laad, 11 parcent
- Nickel, 14 percent
- Iron, 1.5 percent
- Zinc, balance

Leaded nickel bronze—typical:

- Copper, 67 percent
- Tin, 4.5 percent
- Lead, 5 percent

- Nickel, 21.5 percent
- Zinc, 10 percent
- Iron, 1 percent
- Manganese, 1 percent

As the nickel increases, the melting and pouring temperature increases. For 14 percent nickel, the pouring temperature for medium size castings would be 2200 F. For 17.5 percent nickel, 2260 F.; 21.5 percent nickel, 2300 F.; and for 24 percent nickel, 2400 F.

leaded red brass The most common leaded red brass is called ounce metal or 85 three 5's: 85 percent copper, 5 percent tin, 5 percent lead and 5 percent zinc. It is .318 pounds per cubic inch and has a 3/16 patternmaker's shrinkage per foot. The pouring temperature for light work is 2100 F. to 2300 F., for heavy work, 1950 F. to 2150 F. It can be deoxidized with 15 percent phosphorous copper, 1 to 2 ounces per 100 pounds.

An easy alloy to cast for general work. When the tin content is below 4 percent and the zinc increases it is called *semi-red brass*.

Semi-red brass-typical:

- 78 percent copper
- 3 percent tin
- 7 percent lead
- 12 percent zinc

leakers Castings, when subjected to hydraulic pressure, leak through the casting walls. This can be caused by many factors such as pouring temperature, gas porosity, wet molds, design, shrinkage porosity, or a chaplet which did not fuse or burn in properly. In short, it is an unsound casting. More often than not the fault lies in the casting design.

lead sweat High lead tin bronzes containing 15 to 27 percent lead are inclined to bleed or sweat lead. Also they have lead segregation. Excess gas absorption during melting will accelerate this condition. It cannot always be cured with excessive phosphorous copper additions (to deoxidize). It helps to add a small amount of

lead oxide or copper oxide to melt 3 to 5 minutes before pulling the pot.

Remembar that these alloys start to melt at 620 F., the melting point of lead. If you shake the casting out of the mold hefore it gets down helow 620 F., it is going to hleed all tha laad out from between the copper crystals and leave you with a laad-coated copper sponga. It is hest to leave these high lead castings in the sand until thay are at room tamparatura.

leaves in core Strange as this may seem, hlowing and gas porosity in a casting ara often traced to leaves, roots, coke, and coal in the core sand. When using a raw heach or laka sand, if you do not huy washed and dried silica sand, check your sand for organic mattar. It migbt be so very finaly divided that it can ascapa detection. Check using the loss to ignition test to determine bow mucb trash is present in the sand other than silica.

lifting force Tha lifting or huoyant forca on tha copa is the product of the horizontal area of the cavity in the copa, tha haight of the head of matal ahova this area, and the density of tha metal. This lifting forca on tha copa has to ha reckoned with. If tha forca is greater than tha weight of tha cope, tha cope will ba lifted by this forca when the mold is poured and run out at the joint, resulting in e lost casting plus a mess. In ordar to datarmina how much weight has to ha placed on the cope, if any, to prevent a lift of tha cope we multiply tha araa of tha surface of the matal pressing against the cope hy the depth of the cope ahova the casting and the product hy 0.26 for iron, 0.30 for hrass, and 0.09 for aluminum. These figures represent tha waigbt in pounds of 1 cuhic inch of iron, hrass, and aluminum respectively.

If you ara casting a flat plate 12 × 12 inchas, tha surface area against tha cope would be 144 square incbas. If this was molded in a flask which maasured 18 × 18 inches with a 5-inch cope and the metal you ara casting is red hrass, you bave 144 × 5 inches (the beight of tha cope), times 0.30 (tha weight of 1 cuhic incb of brass). You wind up with a lifting force of 216 pounds. One cuhic inch of rammed molding sand weighs 0.06 pounds. So with that factor, tha cope weight would be 18 × 18 × 5 inches times 0.06 or 97.2 pounds. If you subtract the cope weight from tha lifting force of 216 pounds minus 97.2 pounds, you are still short hy ahout 119 pounds. This is the waight you must add to the copa to prevent it from lifting with no safaty factor. With a 20 parcent safety

factor, add 24 more pounds. You should put 150 pounds on the cope.

lifting hook (flasks) Sea also *grab hook*. A hook or pad eya attached to a large flask for lifting or rolling over (Fig. L-5). A flask trunnion is sometimes called an *open lifting hook*.

lifting plates Matal plates let into a pattern with a tapped hola in which a lifting scraw (eye) with mating thread is screwed into to lift tha pattern (Fig. L-6).

light metals Metals that have a low specific gravity such as beryllium, magnesium, and aluminum.

light metal gate tubes Parforated tin tubes used as skimmers in pouring aluminum and magnasium—strainar tubes (Fig. L-7).

lime in molding sand The presenca of excassiva lima in a molding sand is often the hidden cause of gas holes, porosity, pin holes, and blistars in a casting.

liquid contraction The shrinkage occurring in metal in tha liquid state as it cools. Volumatric shrinkage.

liquid parting A liquid used as a parting material in place of a dry or dust type parting, brushed or sprayed on the pattern. Old time liquid parting was bayberry wax dissolved in gasoline. When tha gasolina dissolved, tha pattern was lightly coated with wax.

FIGURE L.5

Lifting hook.

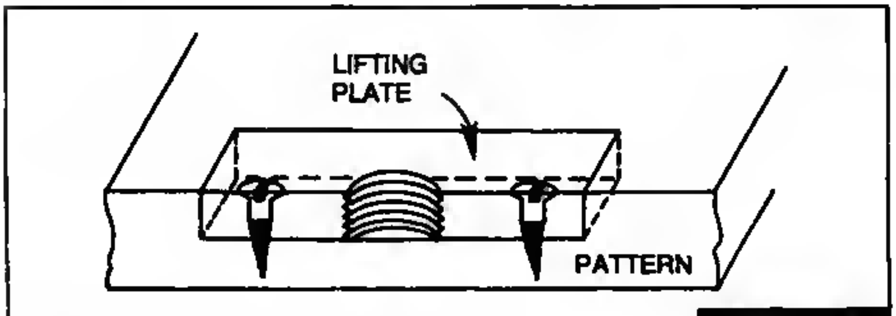

FIGURE L.6

Lifting plate.

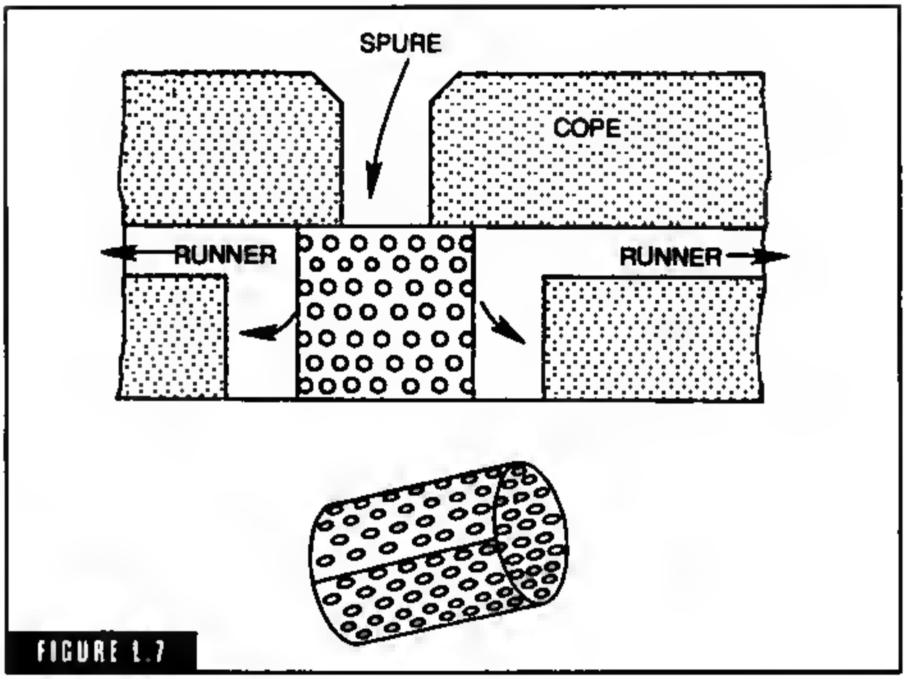

FIGURE L.7

Light metal gate tubes.

There are numerous commerciel liquid partings on the market, ground mice, grephite, waxes, etc. They are dissolved or dispersed in various vehicles.

liquidus The temperetture et which freezing hegins during cooling, or melting ends during heeting.

litharge Leed monoxide, PbO, elso called *massicot*. It is e yellow-to-orange powder used in the foundry to make oil sand followers (oil metch) (Fig. L-8). The most used formule is ½ dry neturelly honded molding sand and ½ dry sharp (core sed). Temper the sand with linseed oil and mix in e smell handful of litharge.

When dry, e litharge metch or follower is rock hard and will take a lot of abuse, lasting for years.

loam molding The production of large molds huilt up with bricks, pletes, and various arbors which are covered with loam and dried to give the form of the cesting desired. Greet skill is required, covering e large variety of foundry knowledge, molding, pettern making, melting, etc.

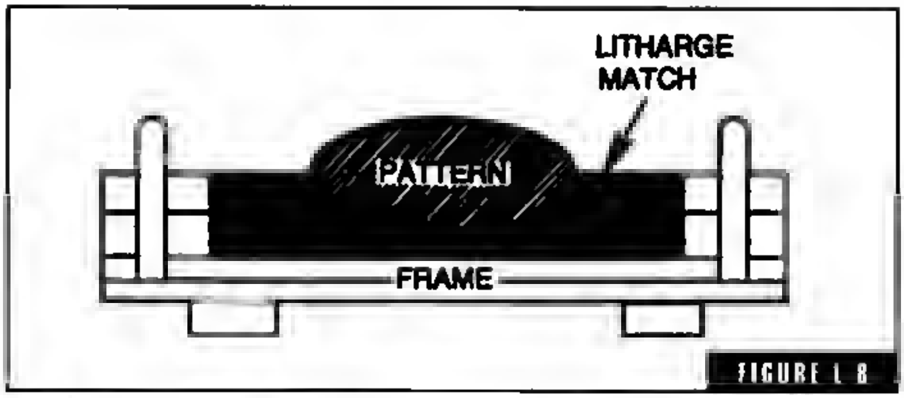

FIGURE L.8

Litharge.

loam sand A mixture of sand, silt, and cley in such proportions es to exhibit sand and cley particles in about equal proportions: 50 percent sand and 50 percent clay and silt.

lock buttons Aluminum huttons riveted to a matchplete directly over a corresponding counterbore recess (Fig. L-9). When the mold is mede and the plete removed, you heve sand projections on one fece of tha mold and corresponding female depressions directly opposite on the other face. When the mold is closed, thesa male and female sand members provide e sand-to-sand lock to help prevent the mold halves from shifting during handling, jacketing, pouring, etc.

loose patterns Unmounted patterns.

loose piece A part of a pattern so attached that it remains in the mold and is ramoved after the main body of the pattern is drawn (Fig.

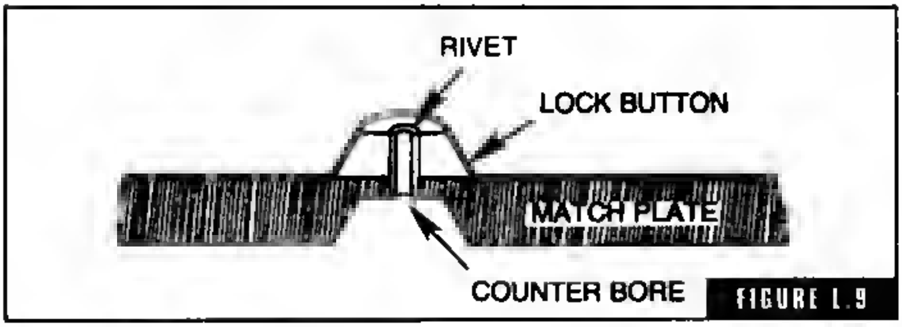

FIGURE L.9

Lock button.

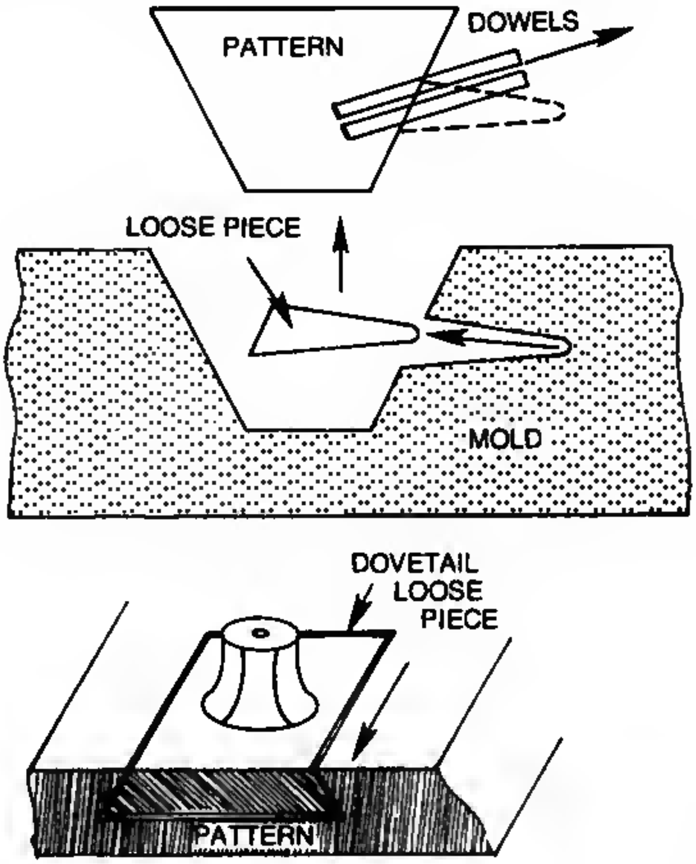

FIGURE L.10

Loose piece.

L-10). The loose piece might be dovetailed to the pattern or pinned on with dowels. If by dowels, the sand is packed (rammed) tightly around the dowels and the loose piece to hold it in position. The dowels are withdrawn and the mold finished in the usual manner.

loss and gain in the cupola The loss or gain of various elements when melting with a cupola varies depending upon its operation or who is operating it; the average, when melting iron, is loss of silicon, 10 percent; loss of manganese, 20 percent; and a gain of sulphur, .03 to .05.

When melting brass; the loss of copper, nil; loss of tin, negligible; loss of lead, 15 to 25 percent depending upon the percent of laad in the alloy. Tha higher the percant, the greater the percent loss and loss of zinc, 50 to 60 percent.

When melting brass or hronze in the cupola, it is best to melt tha copper and tap it into a hot ladle containing the tin, lead, and zinc in the form of shot or small preheated chunks.

loss of ignition The test to determine the percent of material in a molding sand which is lost or burned away during casting. Five grams of the sample sand are placed in a porcelain crucible and beated at 1610 F. for one bour and reweighed:

$$\frac{\text{Loss in Weight}}{\text{Weight of Sample}} \times 100 = \text{Percent of Loss}$$

Too bigh a percent of carbonous or gas-producing materials in a molding sand will cause gas holes, porosity, and pin boles in the castings. The percent is checked by ignition test.

lug An ear-like projection, frequently split as a clamping lug on a tailstock.

lugs, matchplate Metal lugs attached to tha ears of a matchplate that match tha flask pin sbape (Fig. L-11). The lugs follow the drag pins as the plate is lifted (drawn), guiding the plate straight up.

lumber, diamond pattern Pattern lumber with a carved face in various diamond dasigns. This lumber is used to make patterns with a

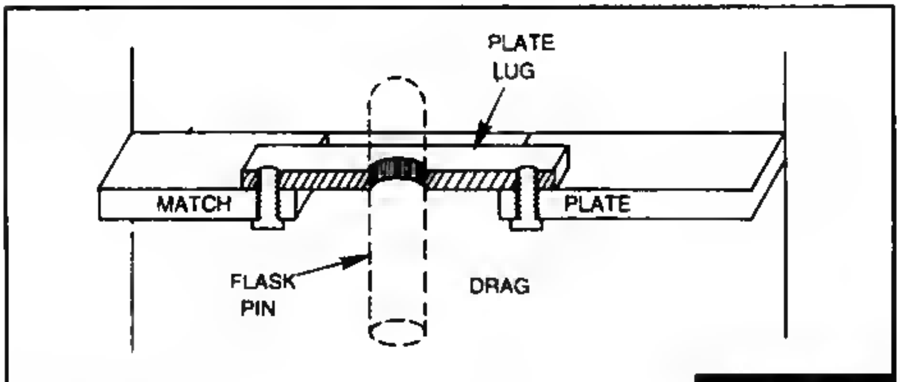

FIGURE L.11

Matchplate lug.

non-skid surface such as treads, sewer covers, catch basins, and similar industrial and street castings. Five different diamond designs are availeble from most petternmaker's supply houses, in thicknesses of ½, ⅝, and ¾ inch thick, 8, 10, and 12 inches wide and in various lengths. The design is mechine carved and clean with ample draft.

lute A mixture of fire clay used to seal crecks such as the creck between e crucible and e crucible cover.

lycopodium A fine yellow powder obtained from e plant known es club moss, cultivated in Russia. It is regarded as the finast and perfect dry parting meterial, used when casting highly ornamental bronze work (es a dry parting). It is expensive, therefore, is used only for special jobs. It can ba purcbasad in soma drugstores.

M

machinability A measure of the ease of machining a metal. The easiest material to machine and that which offers the least resistance to machining would be rated 100. As a material becomes tougher to machine the rating lowers. Where a leaded red brass has a machinability rating of 90, an alloy of 90 percent copper and 10 percent nickel has a machinability rating of 10 or less; white iron 0 to 1.

machine ramming The term used to refer to a mold on a molding machine, slinger, etc., other than hand ramming. The use of pneumatic rammers is considered hand molding.

magnesium A silver-white metal, Mg, 64 percent the weight of aluminum with the specific gravity of 1.74. The melting point of magnesium is 651 C., 1202 F., and the boiling point 1120 C. (Fig. M-1).

Magnesium and magnesium alloys are melted and poured from crucibles made of welded boiler plate in sizes from 60 to 1000 pounds capacity. Small shops melt in the ladle. The ladle simply sits down through a hole in the furnace cover.

Sand used for magnesium casting must be low in moisture and contain inhibitors to prevent oxidization of the magnesium from water vapor. (See inhibitor.)

Multiple gates should be used in place of one or two large gates in order to fill the mold as rapidly as possible to prevent the sand from getting too hot and causing excessive steam. A typical magnesium base alloy for sand casting is composed of aluminum, 9 to 11 percent; zinc, .3 percent maximum; silicon, .3 percent maximum; copper, .10 percent maximum; nickel, .01 maximum; and magnesium, the balance. The tensile strength as cast is 23,000 PSI, when heat treated, it is 32,000 PSI.

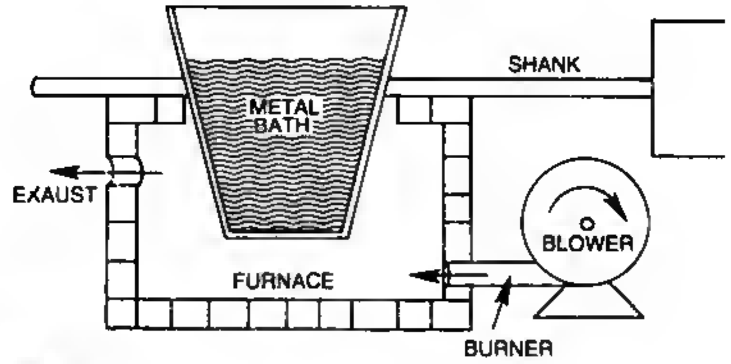

FIGURE M.1

Magnesium.

magnetic brad set A pattern and modal maker's tool used to sat (driva) small wire brads with ease and in bard-to-reach places (Fig. M-2). It is a woodan handled tool aquippad with a hollow tuba which is spring loadad into the handle. The brad is hald in tha tuba by the magnetic tipped plunger. The nose of tha tuba containing tha brad is placad whare you want to sat the brad. Force is applied to tha handle, pushing the magnetic plunger forward as the tube goas back against its spring thus pushing the brad into place.

The brad is pressed in placa with a steady firm pressure. Naver strike or drive the tool. This results in a bant brad and marred surface.

magnetic pulley A pulley used on a sand conveyor belt in farrous foundrias to remove tramp metal such as lost gates and sbot metal from tha sand (Fig. M-3). Because it is a permanent magnet,

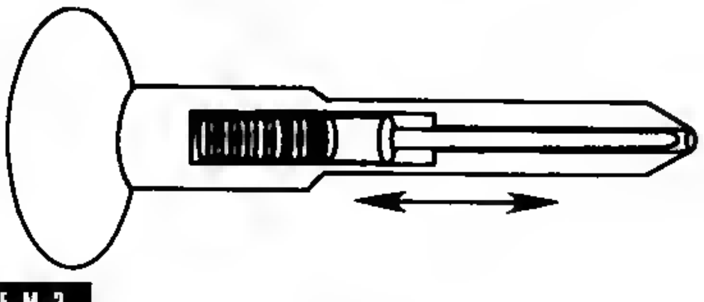

FIGURE M.2

Magnetic brad set.

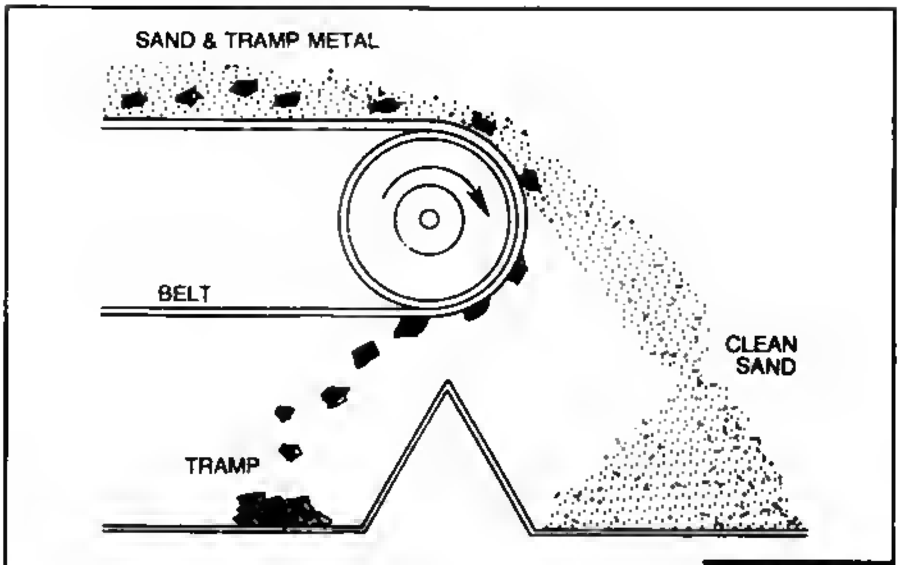

FIGURE M.3

Magnetic pulley.

the sand will discharge from the belt and the tramp iron or steel will continue part way around the pulley due to megnetic attraction. It will discbarge wben the belt carries it away from the megnetic bond or attraction, dropping it off under the belt. Eriez of Canada produces e magnetic pulley with a unique megnetic field which is criss-crossing, rediel, axiel, and diegonel. It eliminates dead spots.

manganese copper An alloy of manganese and copper used for the introduction of manganese into an alloy.

marine animal oils A class of marine oils such es menhaden oil, sardine oil, whele oil, etc. These oils are used in conjunction with e vegetable oil such as linseed oil to produce core oils. (Menhaden oil is made from boiling porgy fisb. Also called white fisb.)

mass hardness A condition in wbicb the entire casting is too hard and unmechineble.

master dowels Male and female dowels used in pattern to ensure a correct and precise register of pettern components while et the same time allowing the components to be freely taken apart or put together for molding (Fig. M-4). Meintains correct register with repeated use, which is not the case with wooden dowels.

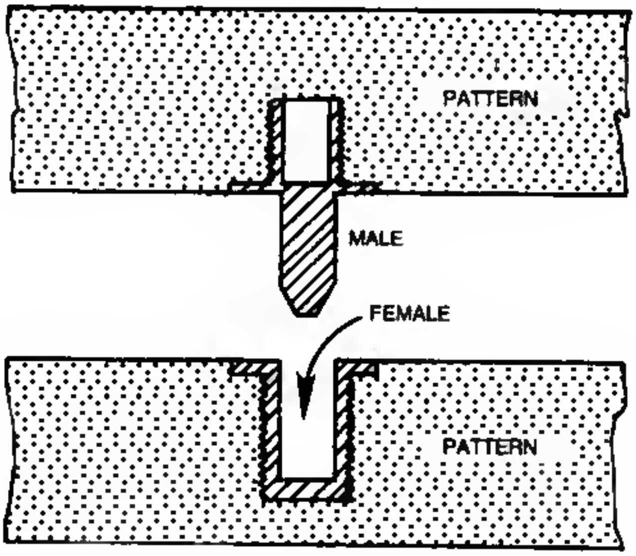

FIGURE M.4

Master dowels.

Mester dowels can he purchesed in e large variety of sizes, designs, and lengths in hrass or steel with the special tools required to instell them.

master pattern A pettern used to cast the production petterns or equipment.

master sheet wax A sheet wax which can he purchesed in e wide variety of thicknesses. It can he purchesed with or without pressure sensitive edhesive on heck. Its uses are too numerous to list. The limit depends upon the ingenuity of the user. The wax can be purchased with melting temperetures from 100 F. to 300 F. in sizes from 8 × 12 sheets to 12 × 24 inch sheets with e thickness of from $\frac{1}{64}$ inches to $\frac{3}{8}$ inches. Its use in the pettern shop is to *log* up e pattern, make e core box pettern from e *core plug*, drier petterns from plugs, or e master pattern from e plug.

In the event only e few castings are required, e plug can he lagged up with sheet wax to the desired metel thickness and shape, shellecked and used es a pattern.

matched partings Forming of e projection upon the meting surface of the cope half of e pettern and e corresponding depression in the surface of the drag.

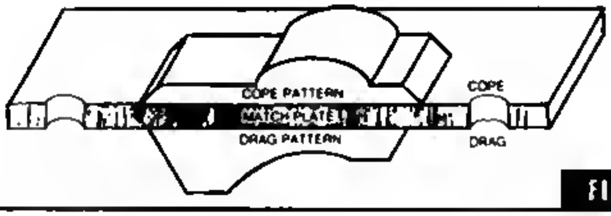

FIGURE M.5

Matchplate.

matchplate The metchplate is the same es the mounted pattern with the exception thet when you heve part of the casting in the cope and part in the drag (split pettern), these parts are atteched to the board or plete opposite each other and in the correct location so thet when the plete is removed and the mold is closed, the cevities in the cope and dreg match up correctly (Fig. M-5).

matchplate flask A large steel flask (very accurate) fitted with lifting screws to make e perfect draw; used to cest metchpletes (Fig. M-6).

matchplate inserts Steel buttons cest in aluminum metchpletes. When they are produced, these buttons are located where the cope and dreg flask rest on the plate during molding (Fig. M-7). Their purpose is to prevent the flesk from wearing the reletively soft aluminum plete et its point of contect.

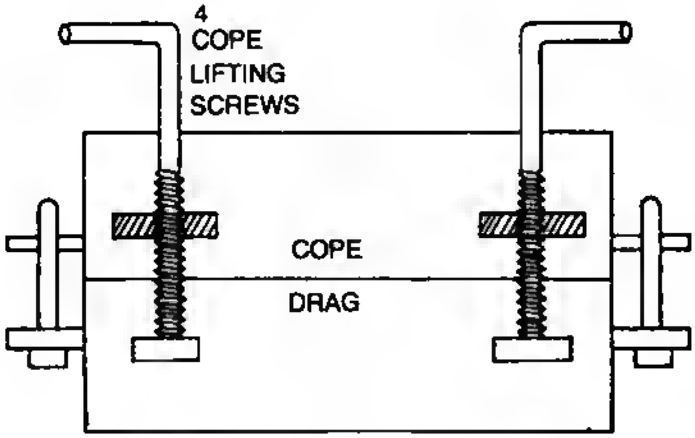

FIGURE M.6

Matchplate flask.

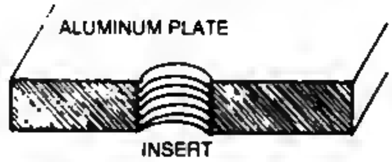

FIGURE M.7

Matchplate inserts.

medium pattern A pattern that is used only occasionally or for casting a ona-tima piece. It is usually constructed as cheaply as possihla. If it is a split pattarn, wooden dowals are used for pins and fit it into holes drillad into tha matching half.

melamine A trimmar of cyanida used to produca a resin hy reacting melamine and formaldehyda. A core hinder.

melting atmosphere Tha atmosphere in the malting furnaca which is reducing (short on oxygen), oxidizing (rich on oxygen), neutral (neither oxidizing nor reducing), or inert by tha introduction of an insert gas into tha melting chamber.

melting loss The loss of metal in tha charga during tha melting opara-tion; it is kapt to a minimum with good sound malting practica.

melting rate Tha waight of matal in pounds or tons melted in ona hour. If a cupola has a rate of 5, it should malt 5 tons of iron per hour at tha tap.

melting ratio Tha proportion of the waight of metal to tha waight of fual in a cupola malting. A cupola malting at a 7 to 1 ratio is malting 7 pounds of iron for each pound of coke.

metallic filler Iron, aluminum, copper, or hrass powdar mixad with an apoxy or resin used to rapair minor defects in a casting faca or surface.

metal penetration This defect should not he confused with an expansion scah, which is attached to tha casting hy a thin vain of metal. A penatration defect is a rough unsightly mixture of sand and metal caused hy tha metal panetrating into tha mold wall or the surfaces of a core (not fusad).

Tha dafect is hasically caused hy a too-soft and uneven ramming of tha mold or core, making the sand too open or porous. A too-high pouring temperature or a corner too sharp (insufficient fillating) makas it impossihla to ram tha sand tight enough, localization of tha ovarheating of the sand dua to poor gating practice, or a mold with a sand that is too opan for tha joh, also causa panetration.

Penetration in hrass castings is sometimes tracad to axcassiva phosphorous used in deoxidizing the metal which makes it excassivaly fluid.

misrun A portion of the casting fails to run due to cold metal, slow pouring, insufficient hydrostatic pressure, or sluggisb metal (nonfluid dua to hadly gassed or oxidized metel).

micro shrinkage The reference to extremely fine micro porosity ceused by shrinkage.

moisture Tha percent of moisture (water) in e molding sand.

mold and core washes These weshes coat the internal sand mold cavity and the surfaca of the core which comes in contact with the hot metal with a *refractory* coating in order to prevent the metal from huming-in. They produce smoother surfaces on the cestings and facilitete the separation of the castings from the sand. This process is known as *peel.* In low melting metals and alloys this is not much of e problem due to the relatively low tempereture involved.

Aluminum can be cast in molding sand whicb is quite fine and with e low refractiveness. It produces a clean smooth surfece and excellant peel. However, because sand cores used in aluminum casting are usually quite open (higb permeebility), the cored cavity will not he nearly as smooth as tha surfece of tha casting in contact with the green sand. The usual practice is to coat the core with a *wosh* to fill in the speces between tha sand greins and present e smooth surface of the metal to lay ageinst. Lead, zinc, and very fluid metels, whicb will ectually seek their way hetween the grains of sand due to a low surfaca tension, are examples of where you would use a mold or core wash.

As a generel prectice it is wise to coet tha portion of all dry sand cores with a core wesh. As tha tamperature of the metal heing cast rises, tha permeahility of the sand must he increased to ellow for the greater volume of gas and steam being genereted to pass through the mold wells and not back through the molten metal (coarser sand). These conditions increase the need for mold and core washes.

Also, when the metal section is quite heavy and subjects the sand to a longer period of heating during solidification, you need a wasb. A ¼-inch brass casting poured at 2150 F. would present no prohlem as to burning or peel, hut the same metel, poured at e lower temperature of 1950 F. and 1- to 2-inches thick in section, would hurn-in badly with poor peel. This also epplies to pouring the metel et an excessive tempereture.

Anothar causa for rough surfaca, poor peal, and burn-in would be a casting poured with an excessively tall sprue and risers above the highest point of the casting. Here we have increased the *hydrostatic pressure* greatly against tha cope surface, causing the metal to penetrata the copa and give a rough surface.

Where you have a casting which is quite large in size and requiras a longer time to pour the section of sand directly balow, the pouring sprua must take the impact and passage of hot metal for a longer interval of time and can be burned and eroded away, wasbing into the casting. Hera again is whera a good wash would be used at the gates into the cavity.

When you have an internal core which is necked down and passes through a wall, even though you ara not concerned with tha appearance or smoothness of the internal cavity, you have what is known as a *hot spot*. Tha cora has to ba washad at this point or tha core could ba badly eroded or coma complately apart.

Learning when, where, and how much to apply a cora wash is laarnad by axparienca and commonsensa.

A mold facing or wash will overcome soma of the problems of a poor sand that has insufficient refractories, but this is foolish finance.

Dry mold facings are also known as *shake-on facings*. Graphite is tha most widaly used.

Cora and mold washes are carbonaceous and carbon free (Table M-1). Binders are organic and inorganic (Table M-2).

In tha proper salection of a mold or cora wash, dry or wat, you are better off with a simpla compound. *Skin dried* molds coma under the same category.

TABLE M.1 Carbonaceous and Carbon-Free Molds.

Carbonaceous	Carbon Free
Graphite	Silica Flour
Carbon Black	Talc
Ground Hard or Soft Coal	Magnesite
Petroleum Pitch	Alumina
	Asbestos
	Mica
	Zircon

Thara ara two ways of accomplishing this treatment. One way is to spray tha mold cavity with a wat binder with or without a carbonaceous or carbon-free ingrediant.

On light-to-medium size castings usually the mold can be simply sprayed (fine spray) with a mixture of 1 part molasses or lignin sulphita to 10 parts of water. Then carefully dry this with a soft flame torcb moving continuously to prevent localizing beat and burning. The mold will then have a dry firm skin upon which the matal can lie. The

trick hera is to dry without burning the binder (molasses or lignin sulphite) and the mold must he poured shortly after skin drying to prevent the moisture in the mold bebind this skin from migrating hack to the surfaca. If this migration occurred, it would defeat the purpose. For heavier work or higher melting metals you can add graphite, talc, or any one of the hases and proceed just as described.

TABLE M.2 Binders.

Organic	Inorganic
Starches	Clays
Dextrin	Bentonites
Sugar	Silicates
Molasses	Oxychloride
Rubber Cement	
Linglin Sulphite	
Glucose, etc.	

A very good method wban using green sand cores made of the same sand tha mold is made from is to dry the core completely. Dry it in a cora oven 350 to 400 F. until dry through and through or overnight. When the coras are ramovad from tha ovan thay ara vary fragile, crumbly, and cannot he handled at all. If sprayed while hot with molasses, or lignin sulphite when cold, they have a nice firm skin and can ba sat in tha mold. Here again you should pour tha mold shortly aftar closing to pravant moistura in the mold from migrating to tha cora.

Tha coras must ha cold. A hot cora sat in a cold mold will cause condensation and hlow.

This systam is not chaap but doas a very excellant job. The cores sbake out aasily, leaving a clean smooth defect-frea surface. On thin wall castings, thay can't ba baat.

In placa of skin drying tha mold hy spraying and torch drying, you can mix tha binder with enough sand to cover the pattern with a layer ½-to 1-incb thick. Finish tha mold with floor hacking sand and then dry the mold faca with a torch.

Tha hinder can he molasses, lignin sulphite water, dry goulac, dry lignin sulphite, glucosa, rosin, etc.

It is common practice to use a facing sand in many cases that is not skin dried but can consist of maraly naw sand, or sand mixed with sea coal, pitcb flour, wbeat flour, etc., and backed with flour or systam sand.

A typical facing sand mix consists of 3 parts air float sea coal; 1 part goulac; and 10 parts molding sand. Another mix consists of 15 parts sharp sand; ½ part bantonite; and 3 parts system sand.

In some classes of work, the molder works with two sands, ona for facing and a coarsar sand for hacking. This can cause

trouble as the two eventually become so mixed together in the system that it all becomes useless.

moldability Tbis cbaracteristic is ralatad to the nature of the bonding clay and the fineness of tha sand.

Becausa tha base sand detarminas tha resulting finish of the casting, it should be selected with care, keeping in mind the type, weight, and class of casting desired. The three or four types of screened sands formerly used for a base bave given way to the practice of blending one coarse sand with a fine one, which results in a better grain distribution. It has been found to produce a better finish and texture. Eacb of the two sands selected sbould bava a good grain distribution within itsalf. Contrary to popular beliaf, additives of an organic or carbonaceous nature do not improve tha finisb but only furnisb combustibles resulting in batter peel.

motd clamps Floor molds ara always clamped to pour. Somatimes thay are waightad, sometimas not, but always clampad (Fig. M-8). Tbere are two basic types of clamps used.

The *C clamp* is cast iron or square steel stock. In operation tha bottom foot is placed under tha bottom board and a wedga (wood or steel) is tapped batween tha top foot and the top of the flask side.

A better practice is to placa two wedges between the clamp foot and flask by band, then tightan tham with a small pinch bar.

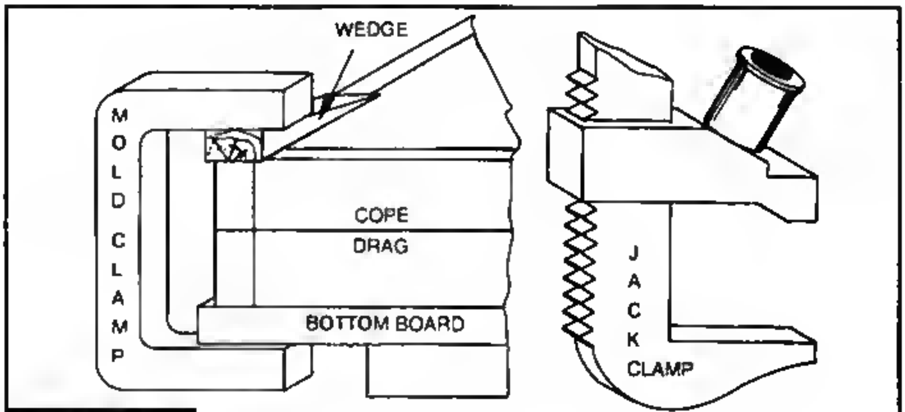

FIGURE M.8

Motd clamps.

Driving them tight jolts the mold and could ceuse internel damege, sucb es a drop.

Tbe jack clamp is the preferred, but most expensive clamp. Its operation is simple. Tbe foot is pleced under the bottom board and the clamping foot is slid down egainst the cope flesk. A bar is pleced in the cam lever and pusbed down until the clamp is snug and tight.

molder's bellows Tbere are two types of bellows—one e sbort snout or bencb bellow and one a long snout floor bellows (Fig. M-9). The theory is that a molder can wreck e bencb mold blowing it out with e long snout floor bellows by hitting the sand with the snout. This theory is true due to the different stance and angle when blowing e mold bench high or on the ground. With care one only needs e 9- or 10-inch floor bellow to blow out cope and drag molds, sprue bole, and getes.

molder's blow can The blow can is e simple mouth sprey can used to epply liquid mold coets and wasbes to molds and cores, or to ep-

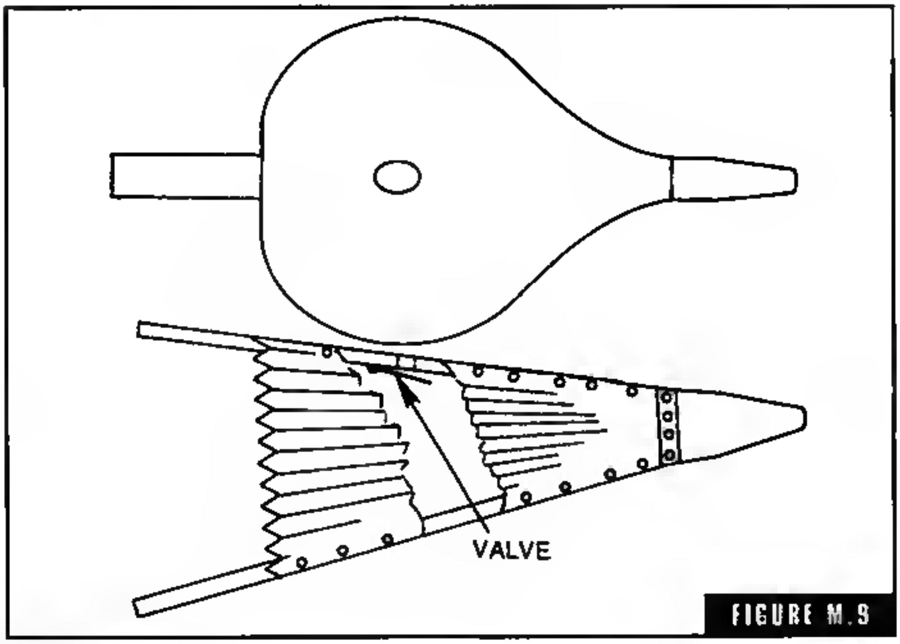

FIGURE M.9

Molder's bellows.

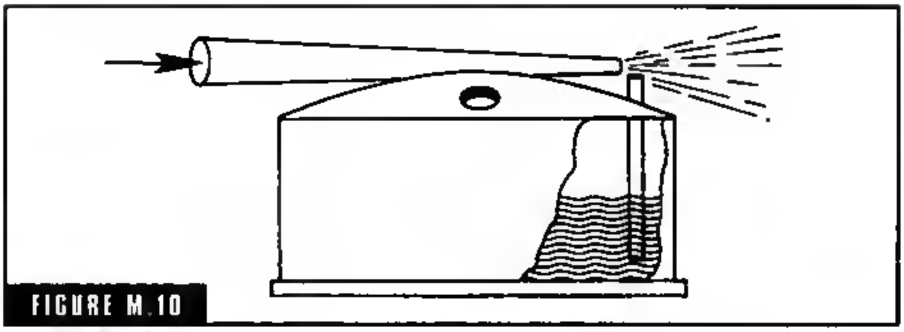

FIGURE M.10

Molder's blow can.

ply water to dampen e large area (Fig. M-10). It can also be oper-eted with the air hose like the sucker.

molder's shovel A sbovel 38 inches long with a 9 × 12-inch flet blede. The handle is wedge sheped into e peen and e rubber piece is dovetailed into e cest bandle (Fig. M-11).

mold anchor Mold anchors are used to prevent shifting between the cope and the drag of molds made in slip or snap flesks (Fig. M-12). After the pattern has been drawn, but before the mold is closed, one end of the mold anchor is pressed into the sand of the dreg and the cope is closed on the other end, securely locking the cope and dreg in perfect elignment. Mold anchors can be pur-cbased or made. Tbey are made of sheet steel or tin plete.

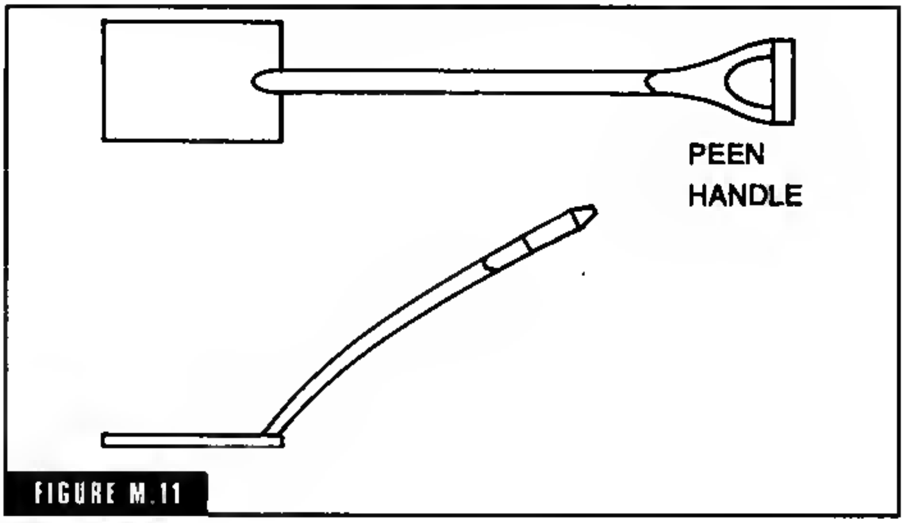

FIGURE M.11

Molder's shovel.

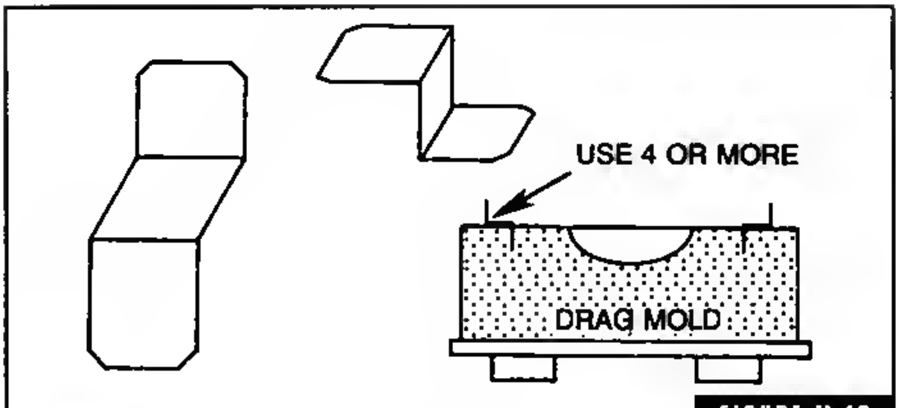

FIGURE M.12

Mold anchor.

mold hardness gauge A spring-loeded dial indicetor geuge used to determine the mold bardness (Fig. M-13). The geuge is marked off from 0 to 100. The geuge measures the depth or amount of depression e convex shaped plunger makes when pressed down on e mold surfece.

In operation the geuge is pressed down until the base anvil is level with the sand and the reeding taken from the dial. The mold hardness gauge has a brake button whicb freezes its action. Readings mey be taken in e deep pocket by epplying then withdrewing the gauge. An excellent tool to not only gauge mold hardness but locete soft spots and uneven ramming.

molding board The molding board is a smooth board on which to rest the pattern and flask when starting to make a mold (Fig. M-14). The board sbould be as large as the outside of the flask and stiff enough to support the sand and pattern without springing wben the sand is rammed. One is needed for each size of flask. Suitable cleats are nailed to the underside of the board. Their purpose is to stiffen the board and to raise it from the bench or floor to allow you to get your fingers under the board to roll over the mold.

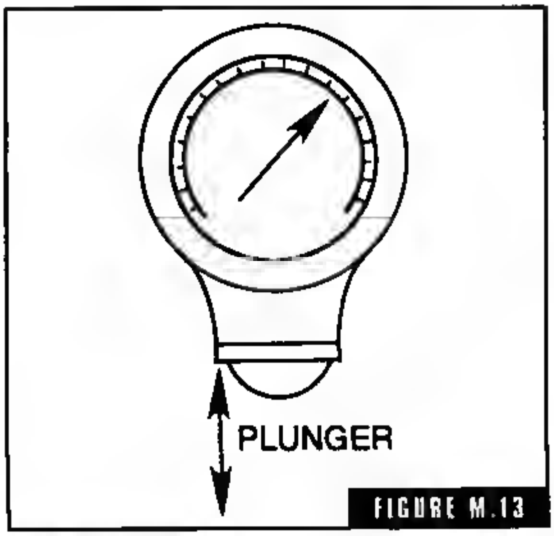

FIGURE M.13

Mold hardness gauge.

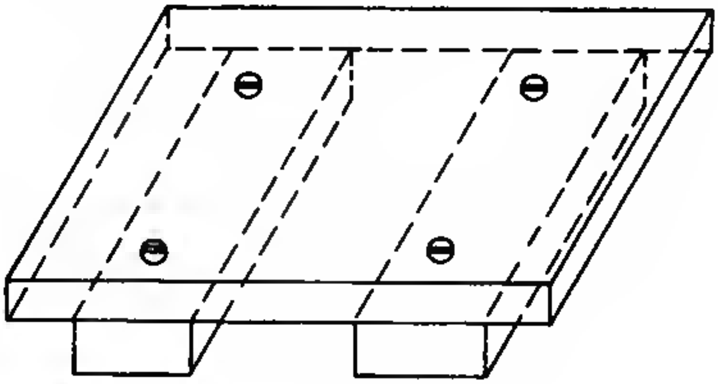

FIGURE M.14

Molding board.

mold shift A shift or misalignment between the copa chaek and/or drag sections of a mold causing a likewise shift in the casting.

mold weights All snap flask work is waightad before molding. In most casas all that is naeded is a standard snap waight, which is usually cast by tha foundry to suit their own snap sizes (Fig. M-15).

The snap flask mold weights are from 1½ to 2 inchas thick cast iron and waigh from 35 to 50 pounds for a 12 × 16-inch mold.

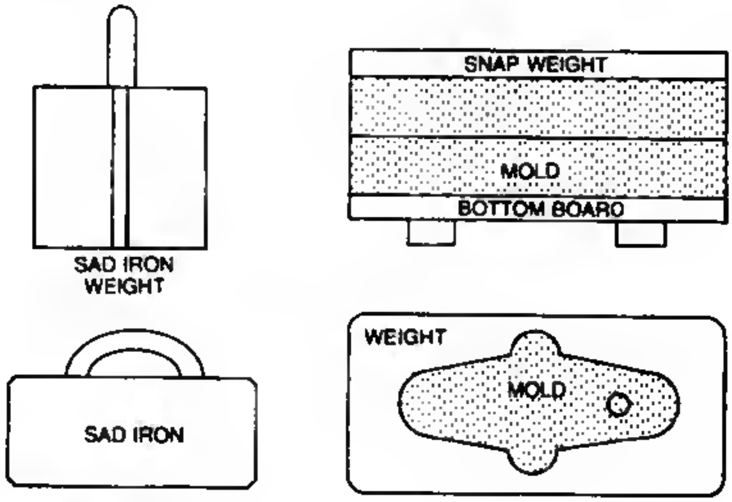

FIGURE M.15

Mold weights.

The rounded cross-shaped opening through the weight is to accommodate pouring the metal into the mold. The weights are always set so thet the pouring basin is easy to eee and pour. It should not be too close to the weight.

In some cases two or more stacked weights are used per mold.

Another type of mold weight which I favor for enap and small rigid flask bench work is the *sad iron* type of weight. They look like irons heeted on the etove for preseing clothee, except thet they are quite a bit heavier.

molybdenum A silvery-white metal, Mo, occurring chiefly in the mineral molybdenite and as a by product from copper ores. Its widest foundry use is in steel to reduce grain growth. In cast iron, it inhibits the decompoeition of austenite to produce e strong fine-grained iron. In both steel and iron it is commonly alloyed with other elements such as nlckel, chromium, manganese, copper, and vanadium.

monel A natural alloy produced directly from Canadian Bessemer Matte hy the reduction of nickel ore, or produced hy alloying. The average composition is 67 percent nickel, 28 percent copper, with the remaining balance of 5 percent iron, manganese, and eilicon. Its melting point is epproximately 2460 F. It can be cast, rolled, or forged. 65,000 PSI tensile up to 100,000 PSI (cast); 50 percent elongation.

motor chaplets A riveted head. Round or square-headed chaplet. Some have a round head on one end and square head on the other end. Others have a sprig or peg on one end to locate it in a hole in e core (Fig. M-16).

mottled cast iron Cast iron consisting of a mixture of variable proportions of gray cast iron and white cast iron. It has a mottled white and gray fracture.

mounted pattern When a pattern is mounted to a board to facilitate molding, It is called e mounted pattern. In this case the mount guides on each end match up with the flask used to make the mold. The plate is placed between the cope and drag flask. The drag is then rammed end rolled over. The cope is now rammed and llfted off. The plate with the attached pattern is lifted off the drag half. The mold is then finished and closed.

muller A sand mixing machine which conditions and mixes the sand by the mulling ection of one or more large flat-face wheels rotating in a tub, but not touching the bottom (Fig. M-17). Plows direct or

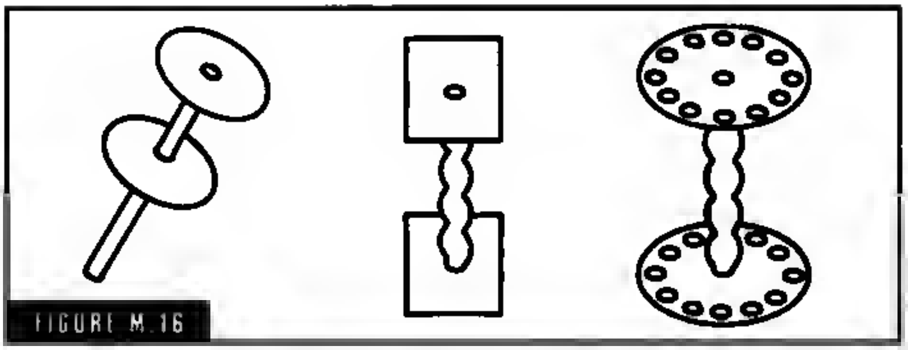

FIGURE M.16

Motor chaplets.

windrow the sand in front of the mulling wheels, which mull the sand with e smearing ection as they roll over the sand. Some mullers are constructed so that the tub rotates and tha wheels are stationary. Others have the tub stationary but the wheels travel in a circle.

multiple molds A composite mold mede up of stacked sections. Each produces a complete gate of castings and is poured from a single sprue (Fig. M-18). The top of one section forms the drag of the section ebove it and the cope of the section below it.

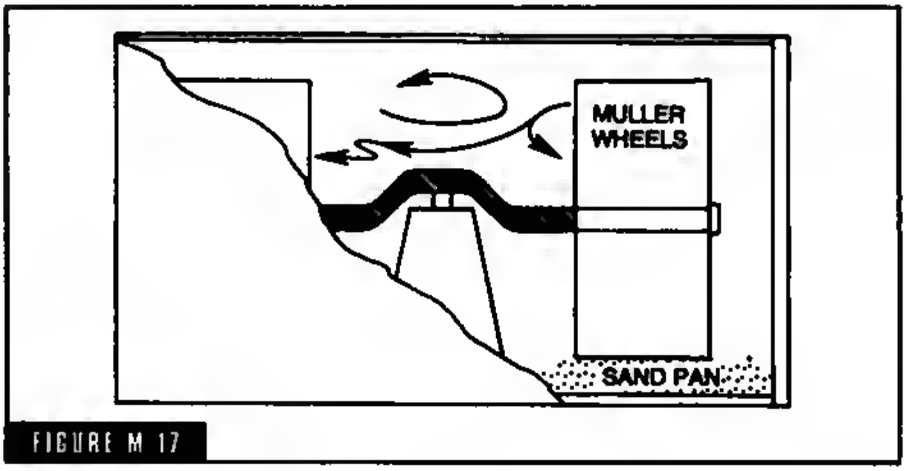

FIGURE M 17

Muller machine.

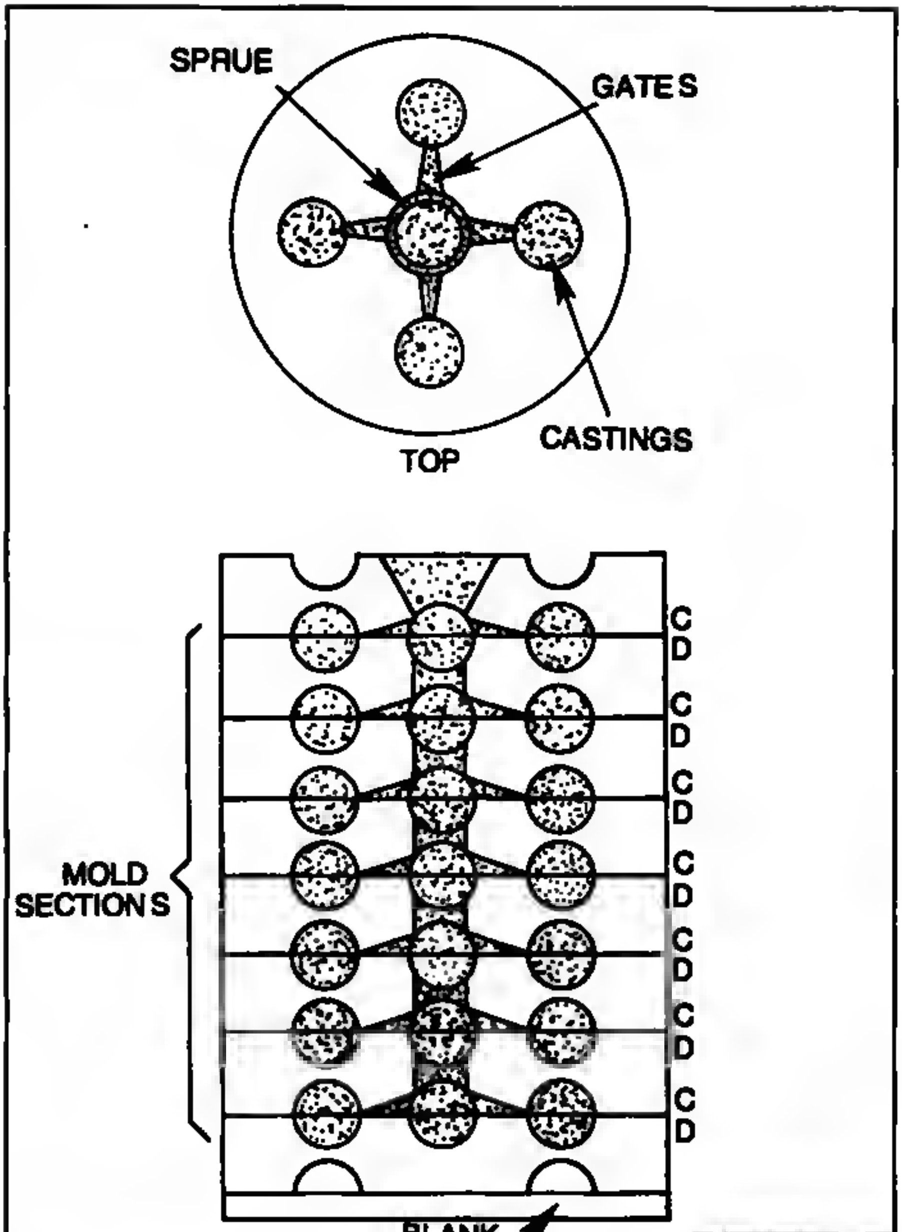

FIGURE M 18

Multiple molds.

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natural molding sands Contains from 8 to 20 percent natural clay. The remaining material consists of a refractory aggregate, usually silica grains.

Any natural sand containing less than 5 percent natural clay is called a *bank sand* and is used for cores or as a base for synthetic molding sand.

Commercial molding sands mined by various companies usually acquire the name of the area where they are mined. The most popular naturally bonded molding sand is called Albany. It is mined in several different grades by the Albany Sand & Supply Co., Albany, N.Y. The origin of this sand is from the Pleistocene ice sheet of approximately 20,000 years ago which swept down from the north and completely overran what is now known as the Albany District. The result, after eons, is a seam of fine molding sand approximately 15 inches thick directly under an overburden of 8 inches of top soil.

neck down cores A core used to neck down a riser at its point of contact with the casting to aid in its removal. In turn, it defeats the action of the riser to some extent because the neck is first to freeze (Fig. N-1). Long skinny necks on risers render the riser useless.

neutral refractories A refractory which is neither definitely acid or definitely basic. Chrome refractories are the most nearly neutral of all commonly used refractories. Of course you have changes at high temperature due to chemical reaction, thus the use of the term *neither definitely.*

nichrome An alloy of nickel and chrome used to produce electric heating elements and parts subjected to high temperatures, kiln furniture, etc.

nickel A silvery-white metal with a yellowish cast isolated in the year 1751. It has been used in alloy with copper since ancient times. Specific gravity of 8.84, melts at 2646 F. Widely used as an alloy in

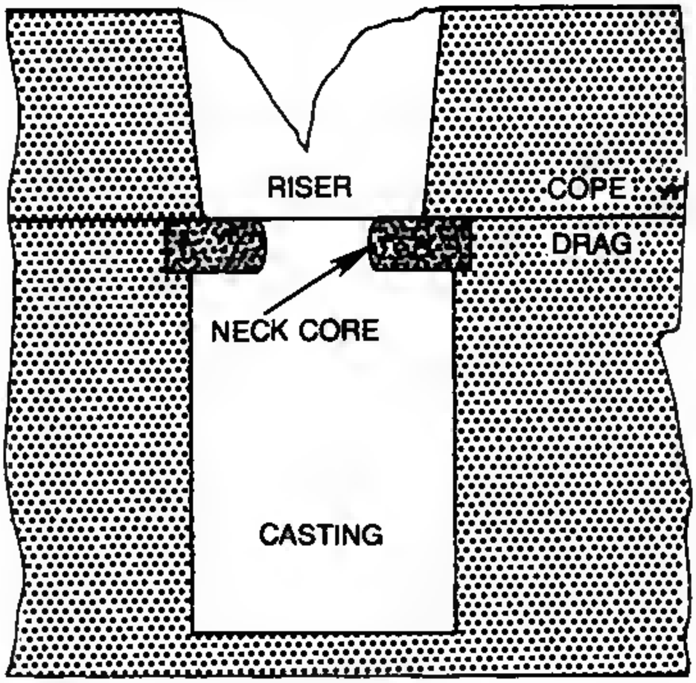

FIGURE N.1

Neck down core.

both ferrous and nonferrous metals. The uses of nickel could fill many a volume: nickal brass, nickal cast iron, nickel steel, nickel bronze, nickel chrome alloys, nickel plating, etc.

nitriding The process of case hardening, where a ferrous metal is heated in contact with a nitrogenous material or in an atmosphere of ammonia. It produces surface hardaning by the absorption of nitrogen.

nodular graphite Frea graphite in cast iron in the form of nodules or spheroids (nodular iron).

nonsilica parting compound A dry parting containing no free silica, usually made of a high melting wax powder.

normalizing Heating a ferrous alloy casting to above its transformation temperature and allowing it to cool slowly at room temperature in still air. Reduces internal stresses. Also called *stress relieving.*

normal segregation Concentration of alloying constituents that have low malting points in the portion of the casting that solidifies last.

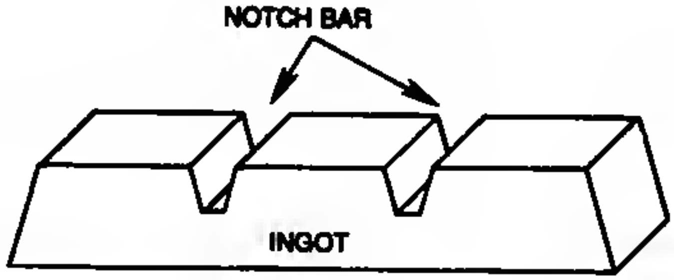

FIGURE N-2

Notch bar facilitates breakage.

notch bar Small-size ingots with notches to facilitate breakage (Fig. N-2).

nowel A colloquial term for the drag mold, not often used except by old timers.

nozzle opening The opening in the bottom of e Bessemer ladle through which the metal is teemed when the nozzle stopper is lifted.

nugget A small mass of metal, such as sllver and gold, found in nature.

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O

odd side A flask or frame used to support a loose pattern to establish an approximate parting during the ramming of a cope or drag. Afterward, the mold being made is rolled over and the odd side is removed and shaken out. It is replaced with a cope or drag section and the mold is completed as usual. The odd side is often referred to as a *false cope* or *false drag*.

offset matchplate The area inside of the flask is offset which produces a matching male and female offset in the completed mold which by its locking or mating nature helps to eliminate mold shift when producing snap work (Fig. O-1).

The sure lock matchplate by Kindt Collins, Cleveland, Ohio, accomplishes the same thing as an offset plate only much more accurately by producing a series of male and female matching projections and sockets around the inside perimeter of the flask.

oil no-bake core and mold process A synthetic oil binder mixed with basic sands and chemically activated to produce dri-sand cores and molds at room temperature. It is an acid dehydration or condensation reaction. The oxidation reaction is accomplished chemically rather than by heat and oxygen.

oil oxygen process Used to produce dri-sand cores and molds by the principle of auto-oxidation. The system utilizes both oxidation and polymerization mechanics on a combination of oils containing chemical additives so that the final product is activated with oxygen-bearing materials. It will set (harden) in a predetermined time.

old casting for pattern In some cases a broken or old casting can be used as a pattern to produce a new or additional casting. In the case of a simple casting which leaves its own core and has ample draft, like a cast iron frying pan, this can be a cinch. Large gear wheels have been cast from a broken gear as a pattern by waxing draft on the teeth,

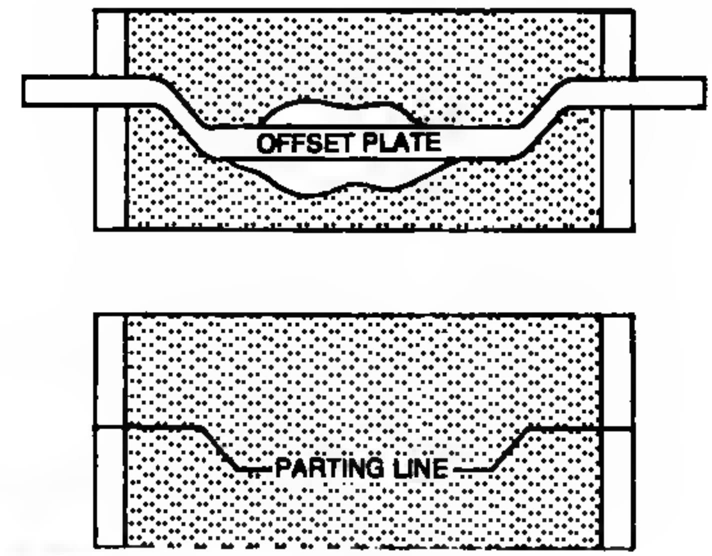

FIGURE O.1

Offset matchplate.

plugging the bore through the bub with a core print, and repping the gear heevily in the mold to take care of the shrinkage. Old mechinery replecement parts are often produced thie wey.

olivine foundry sand A translucent mineral—Mg.Fe. 2.SiO_4. A eolid solution of forsterite and fayalite. Also called *chrysolite*. The choice green stones are used as gems, peridot. Olivine sand is highly refractory. The melting point of forsterite is 3470 F. It is expensive, but an excellent molding sand (when bonded with bentonite) and e greet core sand for the tough jobs. *Olivine flour;* olivine sand ground to e flour makes an excellent investment mix—2 parts plaster of paris, 3 parts olivine flour. Also excellent core and mold washes bonded with molasses water or goulac weter.

omission of a core Results and cause obvious.

open grain structure A defect where the grain is too coarse when mechined or fractured. The causes are many,. including carbon equivalent too high for the eection, leck of carbide stabilizers, pouring too bot (in iron), or pouring too cold. This defect can be throughout the casting or in random spots.

open hearth A furnace for melting metal in which the beth is heated hy tha convection of hot gasses over the surface of the metal and by radiation from the roof.

open sand casting Casting in an open sand mold with no cope. This process is used to cast plates for rigging and where large weights are needed. The big trick in open sand work is in the ramming. The sand must be rammed hard enough to support the weight of the metal; otherwise, without the hydrostatic pressure provided with a cope and sprue height, the metal will kick badly and you wind up with a dangerous mess.

It is very tricky to say the least. It requires much greater skill than molding with a cope. Pouring an open sand mold is also tricky. The trick is to pour from one side, starting a wave of metal across the mold, slacking off and then pouring again in such a way that you catch the returning wave (rebound) with e second weve. You repest this action until the mold is poured.

optical pyrometer A temperature measuring device through which the observer sights the heated object and compares its incandescence with that of an electrically heated filament whose brightness can be regulated. The operator regulates the brightness of the filement until it matches by diseppearing from the screen. The temperature is read on the side of the instrument.

optimum moisture That moisture content which results in the maximum development of any property of a sand mixture.

organic material in melting The gassing and inferior properties of castings (mainly nonferrous) where the scrap, chips, borings, etc., are not completely cleaned of cutting compounds and oils.

over hand The extension of the end surface of the cope half of a core print beyond that of the drag in order to provide clearance for closing the mold (Fig. O-2). It prevents the cope from shaving if not closed completely level.

over iron The amount of iron left in a ladle or excess melted for the floor. This over iron must be kept to e minimum but et the same time it must be short with the heat. In a ladle it can be more costly. It is similar to pouring a 500-pound casting with 450 pounds of metal in the ladle.

oxidation Any reaction whereby an element reacts with oxygen. Combustion by-products and rust are both forms of oxidation.

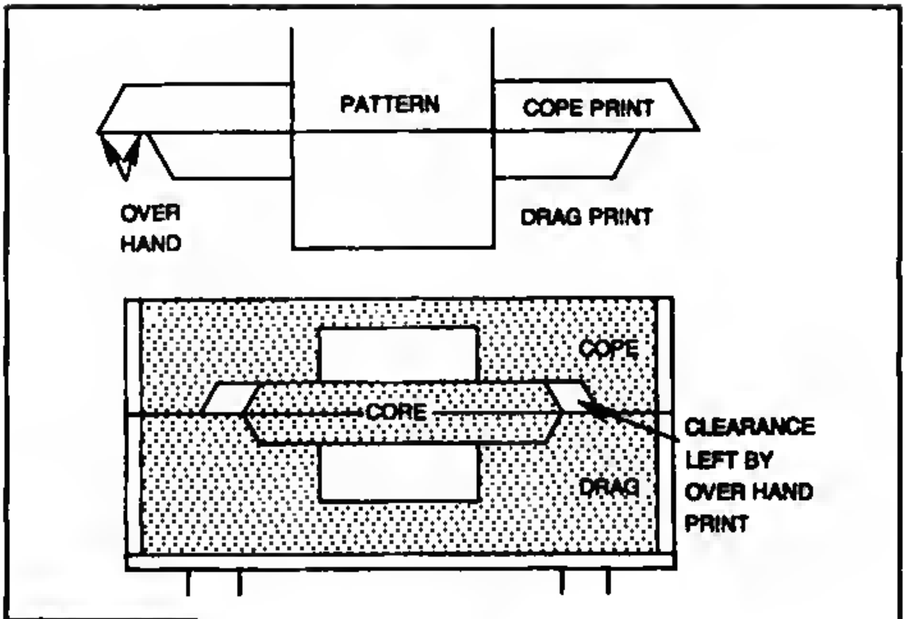

FIGURE O.2

The over hand provides clearance for closing the mold.

oxygen lance A length of ¼- to ½-inch steel pipe connected by a flexible hose to a regulator and oxygen bottle. It is used to burn through steel or burn through a frozen tape hole on a cupola.

P

pad A shallow projection on a casting distinguished from a boss or lug by shape and size only (Fig. P-1).

paddle mixer A sand mixer which mixes the sand with a series of offset metal paddles in a churning action, as a plaster mixer.

parted pattern A pattern made in two or more parts (Fig. P-2).

parting The zone of separation between the cope and drag portions of a mold, flask, or pattern. Also called *parting plane*. The word parting also refers to any material used to effect a parting: parting powder, PVC, parting compounds, etc.

parting compound A material dusted or sprayed on patterns to prevent adherence of sand and to prevent the sand-to-sand joint of a mold from adhering together.

parting line A line on a pattern or casting corresponding to the separation between the cope and drag portions of a sand mold (Fig. P-3).

pasted cores Cores which are made in halves and after they are dried, glued together to make the complete core. If the core is symmetrical, a half box is all that is needed.

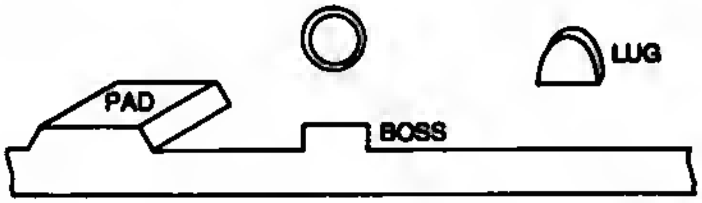

FIGURE P 1

Pad.

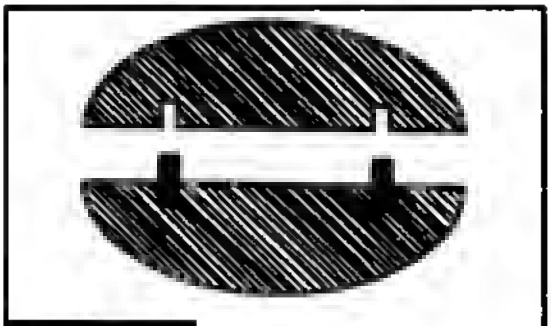

FIGURE P 2

Parted pattern.

After the two halves of the core are dried, a vent is scratched along the centerline of one half and the sections are glued together with core paste. The seam is then mudded with a material known as *core daubing*. Both core paste and daubing can be purchased or made. For homemade core paste, use enough wheat flour dissolved in cold water to produce a creamy consistency.

For a good core daubing, mix fine graphite with molasses water—1 part molasses to 10 parts water. Enough graphite is added to the molasses water to make a stiff mud.

Another good daubing mix is graphite and linseed oil mixed to a stiff mud.

After a core has been pasted and daubed, it is a good idea to return the core to the core oven for a short period to dry the paste and daubing.

pattern board A true surface smooth board reinforced with cleats upon which a loose pattern is laid for ramming the drag.

pattern coating Coating material, like shellac, applied to wood patterns to protect them against moisture and abrasion.

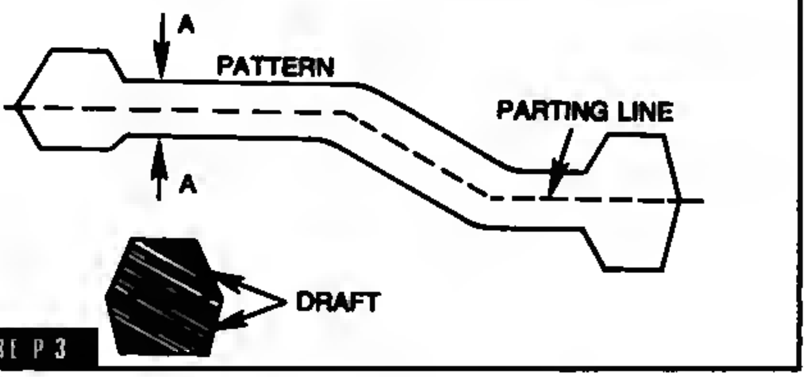

FIGURE P 3

Parting line.

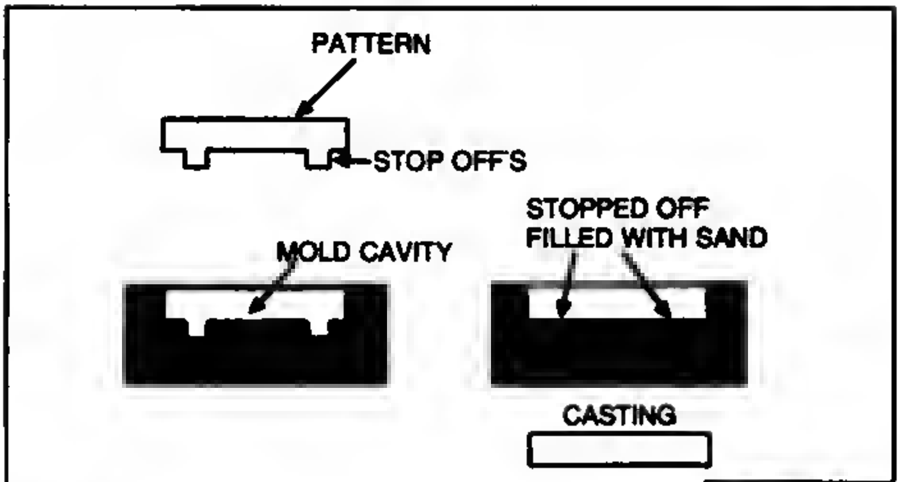

FIGURE P 4

Stopping off.

pattern colors (wood patterns) Petterns are colored to indicate the following:

- Black—Surface to be left as cast (unfinished)
- Red—Surfaces of the casting to ba machined
- Yellow—Core prints and seats of and for loose core prints
- Red stripes on e yellow background—Seats of and for loose pattern parts
- Black stripes diagonally on e yellow background—Stop-offs (Fig. P-4)

By looking et e properly colored pettern the molder can determine if he has all the parts, cores, and exactly how to proceed with the mold making.

pattern letters White metal, brass, or aluminum letters and figures for ettaching to wood or metal patterns for identification, name, directions, etc. (Fig. P-5). The letters can be purchased in e wide veriety of letter styles and sizes from as small as ⅛ inch to 4 inches in size. They can ba plain back, with sprigs, drilled, or with reverse letters for making branding irons. They are used widely to make grave markers, plaques, signs, etc.

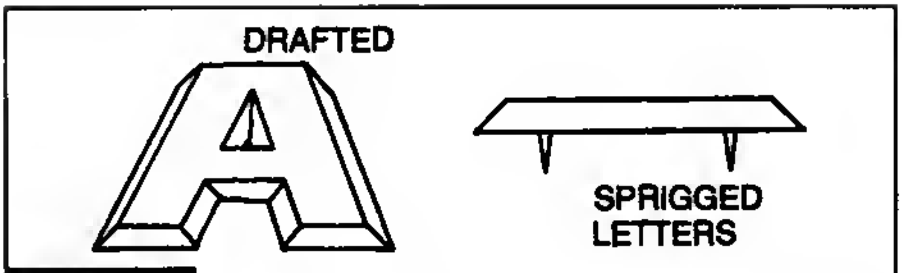

FIGURE P.5

Pattern letters.

Plein beck letters are usually glued to the pattern or sbelleckad. Sprigged letters are attacbed to wood patterns by tapping them down in place with a soft bammer. The sprigs act es brads. Drilled letters are pinned or screwed on to the pettern. Tbe letters are all drafted correctly for molding.

pattern lumber Although patterns can be made of many kinds of woods, most wood petterns are mede of mahogany or sugar pine. Mahogany is usually used for fine delicete wood petterns but is not confined to small patterns. Philippine, African, Mexican, Honduran, Peruvian, and Cuban mahoganies are availabla for usa to the patternmaking trade; bowever, Mexican, Honduran, and the Peruvian grades are by far the most used for pettern work. It is a hard wood, easily carved and worked and will withstand the bard use and abrasion encountered in the foundry exceptionally well. It weighs approximately 3 pounds per board foot and can be purcbased in random lengths and widths from $\frac{4}{4}$ (1 incb thick) to $\frac{16}{4}$ (4 inch thick) in various grades. Tbe better select gredes are used for pattern work.

Sugar pine, a native wood of Californie and southern Oregon, weighs 2.3 pounds per board foot. It is a softer and lighter wood than mahogany. It is widely used and holds up extremely well under use in the foundry. It's also evaileble in a wide range of widths, lengths, and thicknesses. Tbe select gredes are the most used for patterns. Basswood also is good.

For years Jelutong wood was used throughout the rest of the world for pettern work and it is now becoming popular in the western bemispbere. It is a white or straw colored wood with no differential between beart wood and sepwood, e moderately fine

even texture, straight grain, and low luster with the weight of pine.

penetration A casting rough surface defect wbicb eppears as if the metal bas filled the voids between the sand grains without displacing them. It is caused by e too-coarse molding sand for the metal and casting weigbt.

perforated chaptets Tin coeted sbeet steel cbaplets made from perforeted stock (Fig. P-6).

perforated tin sheets Perforated tin plated sbeets of steel used to form various types of skimmers and gates, sold in e wide variety of thicknesses and perforations.

permeability Tbe ebility of the mold meterial to allow steam to pass through the walls. Permeebility can be measured with a meter whicb measures the volume of air that will pass through a test specimen per minute under e standard pressure. Some instruments are designed to measure e pressure differential, which is indicated on a water tube gauge expressed in permeebility units.

permanent motds A mold made of metal or grapbite. It is used repeatedly for the production of many castings of the same form, not an ingot mold. It is usually gravity poured. Ninety-nine percent of all automotive pistons are cast in permanent molds.

Petro Bond Petro Bond is a patented oil bonding system of NL Baroid Industries. Petro Bonded sand consists of fine silica and a maximum of ½ percent of clay (preferebly cley-free) mulled with Petro Bond oil, Petro Bond powder, and P-1 catalyst. Typical green sand properties using a GFN are 140 sand, compression strength 12 PSI, permeebility 15, flowability 87, rammed bardness (mold bardness gauge) 84, and a green deformation in incbes .010 to .014. It is basically used as nonferrous green sand and with excellent results up to and including a 4500-pound bronze casting. Two pounds of iron oxide per 100 pounds sand is beneficial to the correct balance between fine and coarser sand. If Petro Bonded sand is used as a facing sand, it will mix in readily with flour or system sand with no problem.

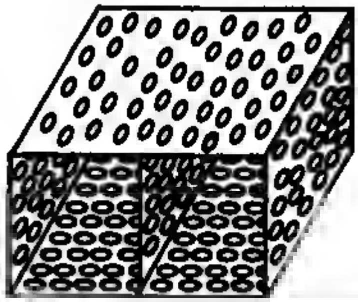

FIGURE P.6

Perforated chaplet.

It bas been my personal experience with Petro-Bonded sand that if just sufficient graphite is added to give it a gray color (2 percent to 3 percent), the results are superior to those with just the iron oxide. It is not nearly as sticky, has excellent lifts, smoother casting surface, the flowability is increased 100 percent, and the mold hardness is improved. Althougb you need a mutter to prepare the initial batch I find it can be kept in shepe for months on end by simply riddling it with a *gyratory riddle*. Most foundry supply houses will supply you with Petro Bonded sand reedy to use (mulled by them).

Although it is no panacea for small hobby shops, for schools with little or no sand conditioning equipment, it is greet. Because of the ebsence of moisture, a finer sand can be used and the problems ceused by moisture are elimineted. Liquid parting cannot be used. Use e good grade of commercial dry parting or use Petro Bond (the dry binder) es e parting.

Some large commerciel foundries beve converted to complete Petro Bonded systems. A typical Petro Bond mix consists of 100 pounds dried silica sand, 5 pounds Petro Bond binder, 2 pounds Petro Bond oil, 1 ounce catalyst P-1 or 100 pounds dried silica sand, 5 pounds Petro Bond binder, 2 pints metro 20 (oil) from Mobile Oil Co., and 1 ounce methanol alcobol.

Petro Bond™ is e registered trademark of NL Industries Inc.

Tbe mixing procedure for Petro Bond sand is divided into three pbases:

1. Weigb out 100 pounds of sand and mix into it 5 pound of Petro Bond. Dump the load into the muller and mix dry for about one minute.
2. Add to the mix in the muller 2 pounds or 2 pints of Petro Bond oil and mull for ebout 10 minutes.
3. Add 1 ounce catalyst P-1 and mix for 3 to 5 minutes longer. With many sands the green strength will be at least 8.5 psi. The green strength required will depend on the type of metel to be cast and the size of the casting to be made. After mixing, the sand can be kept indefinitely.

Tbe time of mixing varies with the type of muller used and can be determined by varying the mixing time until the desired strength is obtained.

In a slow muller the dry ingredients should be mixed for a minimum of one minute. Subsequently, the oil can be added slowly while the muller is in motion and mulled for a period of 10 minutes. The P-1 catalyst is then added and mixed for 3 to 5 minutes. The mix can then be stored indefinitely and will be usable at any time without further treatment.

If this mix results in a stronger sand than desired, it may be cut with clean sand.

As the sand is used it may become contaminated with coarse particles of core sand. If this contamination proceeds to the point where the over-all percentage of fines in the sand is noticeably reduced, it is advisable to add iron oxide during one of the remulling cycles. Such additions help restore the correct balance between fine and coarse sand. The usual procedure is to add the iron oxide at the rate of from 1 to 2 pounds per 100 pounds of sand. This addition will also result in a tougher but drier sand. It may then be necessary to add additional oil to restore proper moldability.

When it is used for the entire mold, after the casting bas solidified and is *shaken out*, it is only necessary to *aerate* or *riddle* the sand before re-using. This sand can be used without remulling until the green strength has been reduced sufficiently to cause scabbing or washing.

Petro Bond sand may be used as a facing for green sand molds. When Petro Bond sand is used as a facing, the burned sand readily mixes with the green backing sand.

For both types of use, best finishes are obtained wben the mold hardness is 80 or higher.

Patterns made of wood, plaster, aluminum, brass, steel, etc., can all be used. Bear in mind that the accuracy and finish of the casting produced can be no better than the pattern. Waxed patterns should not be used until they have been coated with a hard resin or paint.

The following difficulties usually can be eliminated by using the procedures described. If the trouble continues, carefully check all materials, equipment, and process cures being used.

■ Low Green Strength

The minimum green strength of 8½ pounds should be obtained if the mix is adequately mulled.

Improper milling. Tbe formula may be correct and the ingredients good, but the actual mulling achieved may he inadequate. The muller must be clean and dry and have a rough enough surface to provide intensive mixing. Tbe wheels of the muller should be lowered to the pan to give the proper mulling action. Plows thet are too worn will not provide proper mixing. If porteble mulling equipment is being used, the time of mulling sbould be greatly increased (above the time required for mulling by heavier stationary equipment) in order to get a mix of proper green strength.

Petro Bond content too low. Make sure you have used the emounts and the ratio of Petro Bond to oil that is prescribed in the foregoing mixing procedures. Be sure the Petro Bond is uniformly dry mixed and the oil is added slowly to avoid leekege.

Too much moisture in sond. Check the sand to make certein that the moisture content is less than ¼ percent.

Oil is not of the proper type. Recheck the oil being used. Make certain that the oil is of the proper specifications. If the finisbed mix hes a glossy eppearance, it indicates thet the oil is probably not of the proper specifications.

■ Poor Finish of Castings

Incorrect mold hardness. Check your mold hardness. Make sure that its hardness is 80 or better. If you are using e very high green strength in your mix, make certain that the mold is rammed properly to give you a minimum mold hardness of 80.

Wrong parting ogent. Do not use e liquid parting agent with Petro Bond. A dry parting is necessary if loose patterns are used, especially if they are wooden patterns that have been shellacked. Petro Bond can be used as a dry parting.

■ Turbulent Metal Flow or Lack of Effective Choke Feeding

To essure smooth metel flow and adequate filling of the cavity, choke the flow of metal to eliminate turhulence. Most metals can he poured at lower temperatures due to the absence of the chilling effect of water and the lower heat conductivity of the oil.

■ Cutting and Wesbing in Molds

Improper romming of the mold. Make certain thet the mold is rammed hard. Cbeck the in gates and sprues to make sure they are properly cut. If the gates and risers are cut efter the mold hes

been mede, it is advisable to lightly swab the surfece of the cut with the same oil used in the Petro Bond mix. Tbis belps to bind the grains of sand and minimize any washing into the casting. In getes and sprues sbould be smaller in the Petro Bond molds than in conventional sand molds.

Improper pouring of molds. Petro Bond sand molds can be poured et considerably lower tamperatures. If tha surfaca of the Petro Bond mold is very smooth, the flow of metal sbould be reduced or restricted. Tbis can be accomplisbad by using strainer cores or by cbanging the geting system so that the metel enters the mold without turbulence.

■ Non-Uniform Reproduction of Pettern

Improper mold hordness. If it is found thet the cope and dreg surfaces of tha castings ara smooth but tha sida walls are not, it is an indicetion thet the mold bes not been rammed bard enough. The mold bardness sbould be uniform on all the mold surfaces. Cope, drag, and matchplata aquipment giva tha bast raproduction.

■ Out of Dimension Castings

Insufficient cooling time. When castings are removed from the mold too soon there is e tendancy of the casting to warp becausa of non-uniform solidification. It is essential to leeve the casting in the sand long enough to bave it proparly solidified.

■ Gas Problems—Blows, Cold Sbuts, Etc.

Too much oil in the mix—When excessive amounts of oil are used in Petro Bond mixes, the surface of the metal may sbow slight imperfections. To eliminate this condition, mull 2 percent iron oxida into the mix to ebsorb the excess oil. Another method is to rebalance the formule by the eddition of clean silice sand and Petro Bond to bring the mix to the proper green strength.

Check permeobility. Molds mede with Petro Bond are poured et considerebly lower permeebility than molds made with weter-bonded sand. There is, bowever, a minimum level of permeability. Tbis is particularly true wben pouring bigh tempereture alloys. Tbe optimum must ba esteblisbed to give proper cestings.

■ Poor Castings Finisb

Excessive contaminotion by core sond. Result of using same sand over e period of several months. Cbeck your system and see if excessive amounts of core sand are heing introduced.

phosphorous A nonmetallic element, P, widely diffused in neture and found in many rock meterials and ores. In the foundry it is used as e deoxidizer comhined with copper or other alloys to stehilize it so thet it can be handled.

phosphoric acid H_3PO_4 used in pickling and rust proofing. Widely used as the cetalyst in the furan no-hake sand system.

pickle To clean metal by chemicals or electro-chemicels. To remove surfece oxides, etc. An ecid or ceustic solution.

pig bed Small scooped-out pig-sheped excevetions made in an open sand mold or bed to pour off the excess metel from a heet.

pig iron Cast iron produced hy the reduction of iron ore in e hlest furnece.

pinch dog A steel C-sbeped device with sharp points tepered on their inner fece to give e clamping effect when driven into wood (Fig. P-7). The further in, the tighter the clamp (pinching) effect. Used in pettern work to hold one memher to another while gluing, neiling, or drilling. The prime use is in gluing up stock. Some

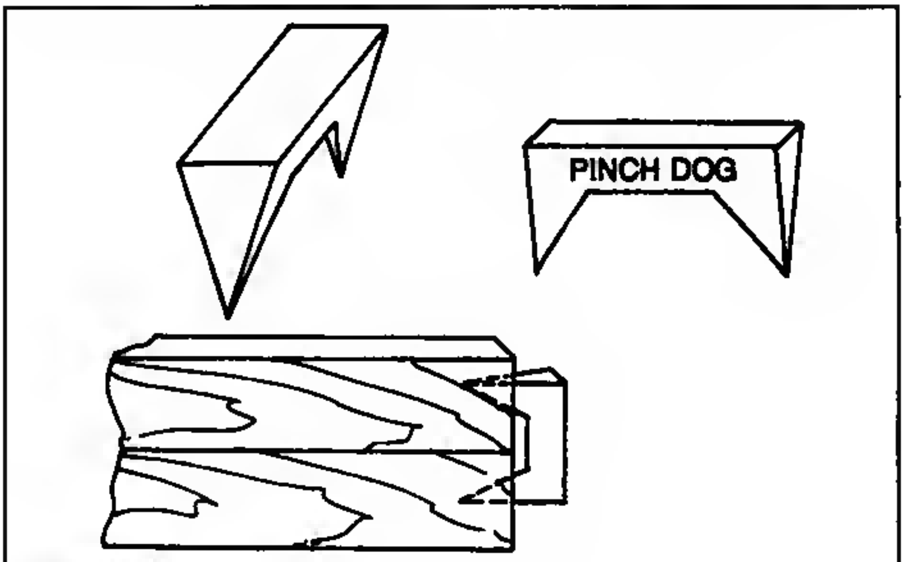

FIGURE P.7

Pinch dog.

patternmakers use them to hold the two halves of stock together when turning a split pattern. This is e very dangerous practice. If they become loose while turning, the centrifugal force will throw them with great impact. You could he seriously injured or killed.

Pinch dogs come in sizes from ½ to 3 inches between points. Purchased from any pattern supply or foundry supply company, they can he used for a variety of tasks.

pin holes Surface pitted with pin holes; may also he an indicetor of suhsurfece hlow holes.

pine tree structure The appearance of dentrites crystal growth in a solidifying metal.

pitch and gilsonite Both of these meteriels are used to produce dry and hot strength along with good hot deformation and as expansion controls. Also used as a hinder for dry sand work and hlack sand cores. It is e haking type of hinder. Most prepared hleck core hinders sold todey under various trade names are usually a mixture of pitch, destrin, lignin sulphite, and resin. To use these correctly you should know the percentage of pitch. Light work pitch is used by percent by weight. When using pitch in dry sand work it must he worked well on the wet side. It is used in skin dry and dry sand work for large aluminum bronze work end dried overnight. Sometimes it is used in comhination with 50:50 with sea coal and also with southern hentonite. When used es e replacement for sea coal, it can he used as low es ½ percent to es high es 4 percent hy weight. The mold hardness, toughness, and green strength increases es does the hot and dry strength. The permeehility decreeses somewhat and little or no effect on the flowehility is encountered. It should he noted that other meteriels are elso used as ingredients in fecings such es lignin sulphite, rosin, graphite, coke, and fuel oil. Gilsonite is a natural pitch much more potent than coel tar pitch and usually is used sparingly in the order of ½ to 1 percent in green sand fecing mixes. It is also used in the manufacture of some mold and core washes.

porosity Unsoundness of a cesting due to the presence of hlow holes, gas holes, or shrinkage cavities.

poured short Casting incomplete due to not filling the mold. Going hack and touching up the mold will not correct it.

pouring basin A hasin on or in the cope to hold the metal prior to its entrance into the sprue.

pouring devices Any device thet is used to handle ledles or crucibles for pouring molten metal. They vary from simple shanks to complex epparatus and automatic robotic devices.

pressure Too low a pressure (hydrostetic) by heving too shellow e cope flask. Thus a short sprue will cause scars, seams, and plates es a casting defect.

pressure tight A casting thet does not leak under pressure. It is free from porosity and unsoundness.

primary crystals Tbe first dentritic crystals formed in an elloy during cooling below the liquidus tempereture.

print back The pettern is removed from the mold and the sand cevity dusted with cement or plumbago. The pattern is returned and repped to set the surface and redrawn. Tbis system is used to produce an extremely smooth casting surface. It is widely used when cesting pleques and greve markers.

progressive solidification The solidification of e cesting from the thin sections the farthest ewey from the sprue toward the sprue or riser (Fig. P-8). It is accomplished by correct design, chills, correct gating, and risering.

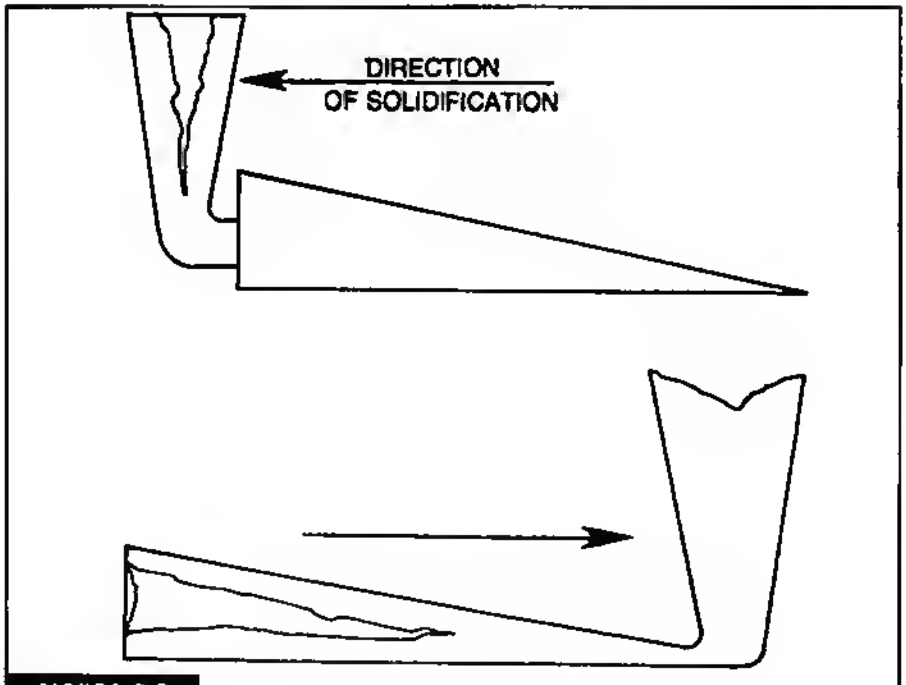

FIGURE P.8

Progressive solidification.

prop The iron post that holds the cupola bottom doors closed.

protein binders Core and mold binders which are organic compounds containing nitrogen.

pull cracks Hot tear.

pull down A sand buckle in the copa dua to excessive expansion of the cope sand. Insufficient combustibles in tha sand (wood flour, atc.).

push-up An indentation in a casting usually on the drag side dua to the displacement of the sand in the mold. Often caused by improperly seated bottom boards, poor clamping practice, or too shallow a drag for the job.

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fault and no content is missing.

Q

quenching Heating a casting to a specified temperature and rapidly cooling it in water, oil, etc., to create a heat treatment.

R

radiant heat The heet radiated from e furnace arch and walls. Also the heat radieted from the molten metal poured into e mold. The ceuse is often metal penetration due to the improper locetion of gates and risers; this promotes locelized overheating of the sand. Pouring a mold with an insufficient numher of getes will suhject the mold surfaces to radiant heat for too long e period and will ceusa the mold surfece to break down. A very common prohlem with investmant cestings which are undergated and prevent the mold from filling fest anough.

radiator chaplets Differ from most other cheplets in thet they are set before the mold is rammed (Fig. R-1). The practice is to drill e hole in the pettern corresponding to tha diameter of tha wire used in the chaplet. The cheplet is dropped into the hola, sand rammed into the mold, and the pettern withdrewn. The stem of the radiator chaplet is left protruding in the mold cavity a distance equel to the thickness of metal and raedy to support or hold down the core in its propar position.

When tha cora is set, it rests against the flet end of the wire stem. In many ceses this does not provide e sufficient haaring surfece when the casting is poured. Additional baaring surfaces can ba obtained hy putting e round or square core plate on tha core, against which the radiator chaplet will press.

Tha most commonly used radiator chaplat has e shoulder and break-off nicks. This drops into the hole in the pettern as far as the shoulder.

ram-away A defect caused by molding with e sand that has poor flowebility and ramming at the wrong angle (Fig. R-2). A section of the mold is forced ewey from the pettern hy ramming sand efter it has conformed to the pattern contour.

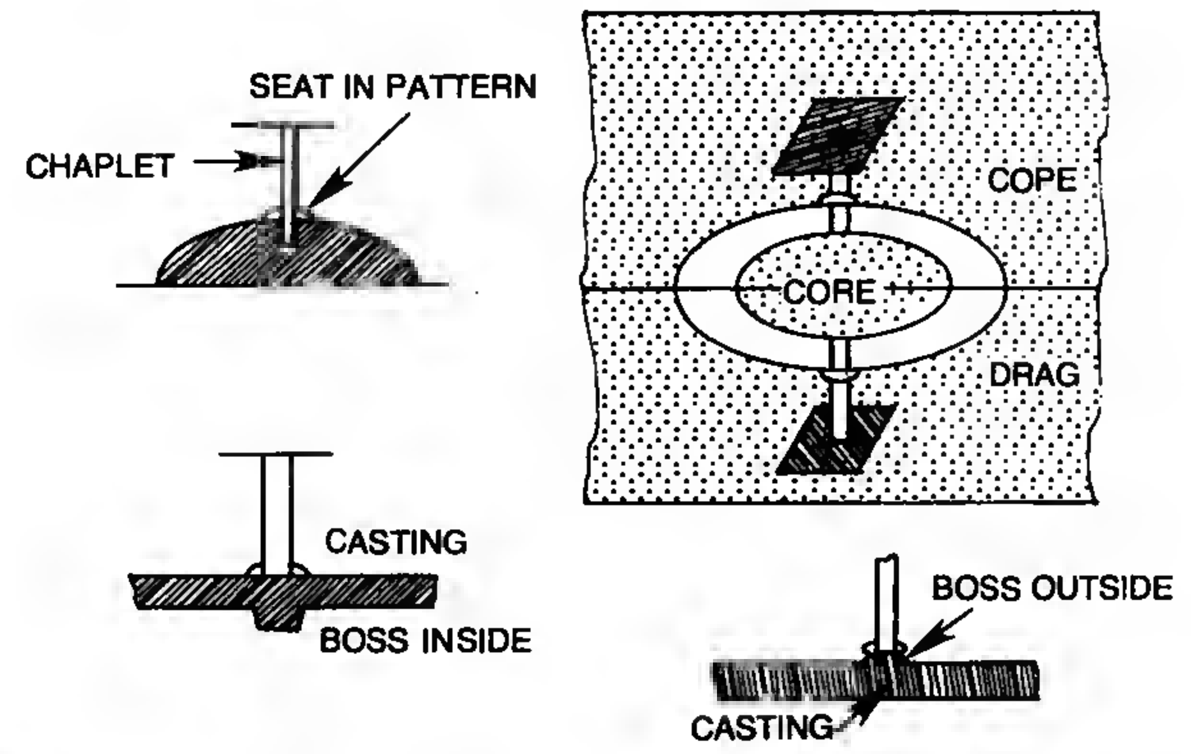


FIGURE R.1

Radiator chaplets.

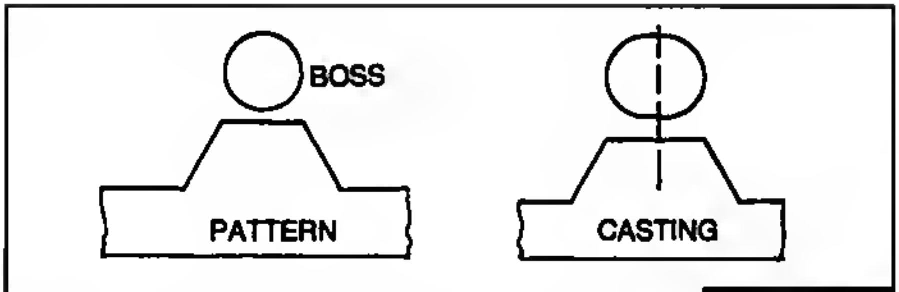


FIGURE R.2

Ram-away.

ram off A defect resulting from a section of the mold being forced away from the pattern by ramming sand after it has conformed to the pattern contour. This is caused by carelass ramming, when the mold is rammad vartically and then on an angla, causing tha vertically rammed sand to slide sideways and leave a gap between the pattern and the sand. It results in a deformed casting. Another causa is using a sand with poor or low flowability.

ram-up core A core set against tha pattern or in a locator slot in the pattern (Fig. R-3). The mold is rammed and wben the pattern is drawn the core remains in the mold.

rapping bar and rapper Tbe rapping bar consists of a piece of brass or steel (cold roll) rod wbicb is macbined or ground to a tapered point (Fig. R-4). The rapper is made of steel or brass and is shaped exactly like the frame of a sling shot.

The purpose of these tools is to rap or sbake the pattern loose from the sand mold in order to draw it easily from the sand. The pattern is shaken in all directions to drive the sand slightly away from the pattern. The resulting mold cavity will actually be a fuzz larger than the pattern. The pattern sbould only be rapped enough to free it from the sand. You will be able to see wben it is loose all around by the movement of the pattern. Over-rapping will distort the mold cavity whicb may or may not matter depending on how close you wisb the casting to hold a tolerance.

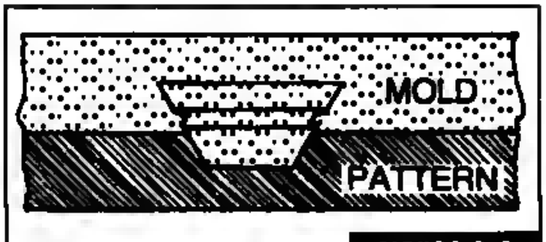


FIGURE R.3

Ram-up core.

The operation is quite simple: the bar point of the rapping bar is pressed down into a dimple in the parting face of the pattern with the left hand. The rapper is used to strike the bar with the inner faces of the yoke.

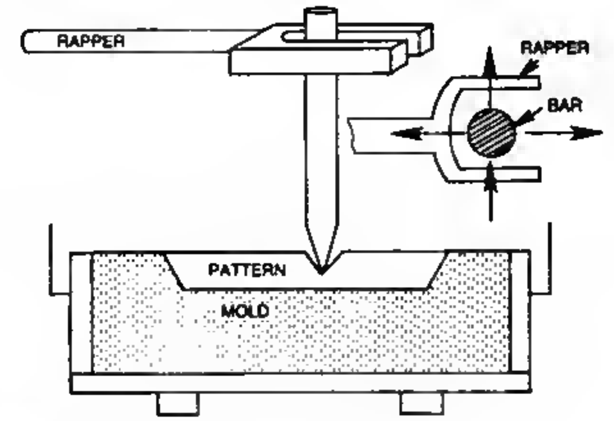


FIGURE R.4

Rapping bar and rapper.

rat A lump on the surfaca of a casting caused by a portion of tha mold faca sticking to tha pattern.

rat tail A minor casting dafect. A small buckla occurring as a small irregular line or lines on the casting surfaca.

receiving ladle Usually a ladla (often stationary in front of the cupola) into whicb tha metal is tappad and wbara any innoculation neaded is done. Tbe pouring ladles are fad from tha recaiving ladle. In this arrangamant the recaiving ladle becomes in fact a tilting forebaarth.

red brass Red brass is dafined as a brass alloy containing 2 to 8 percant zinc with tha tin contant lass than tha zinc. Tba lead content is less than .5 parcant. This alloy is not often usad in tha production of castings. Tba leaded red brasses and semi-red are called red brasses. A laaded red brass is a brass with 2 to 8 percent zinc with a tin content less than 6 percent (usually less than tha zinc content) and laad ovar .5 percent. 85 percent copper, 5 percent tin, 5 percent zinc, and 5 percent lead is callad red brass but is actually a leaded red brass.

red shortness The brittlenass of some ferrous and nonfarrous metals when at a red heat. Referred to as *hot shortness*.

reducing atmosphere An atmospbere whicb is sbort or laan of oxygen.

refractoriness The ability of sand to withstand higb temperatures without fusing or breaking down.

regenerative chamber A system where the air for comhustion is preheated hy regenerative chambers—heeted hrick mazes through which the hlast eir pesses and is heeted. They are constructed in pairs; while one is giving up its heat to the hlast air, the other is being heeted (usually hy the exheust gasses from the melting unit). When the chamher through which the hlast air is heing heated falls below a certain temperature, e series of valves swep the direction of the air and exheust over to the other chamher to regenerate the cooled one.

reservoir A hasin on top of e mold designed to hold sufficient metal to pour the mold. It is opened to the sprue hy e plug, similar to e hottom pour ladle (Fig. R-5).

return scrap Home genereted scrap consisting of getes, risers, chips, and horings from the castings produced. In some cases es with steel, the return scrap from e given casting can he greeter or equal to the weight of the cesting itself.

reverse chill Also celled *inverse chill* (Fig. R-6). The condition in e cesting section where the interior is mottled or white iron with e grey iron exterior. It is usuelly found in thin castings. The usual ceuse is the presence of nonferrous metals in the iron such as antimony, leed, tellurium, etc., or the casting was poured with a too-high carbon equivalent for the section thickness heing poured.

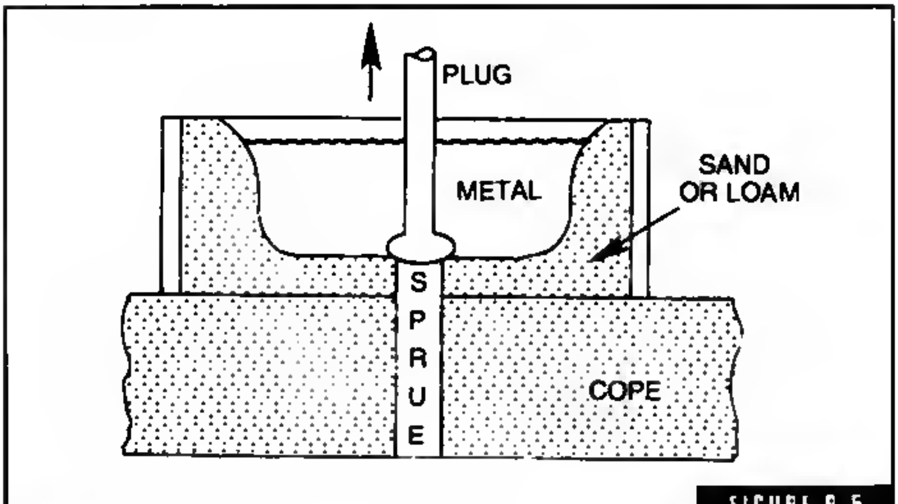


FIGURE R.5

Reservoir.

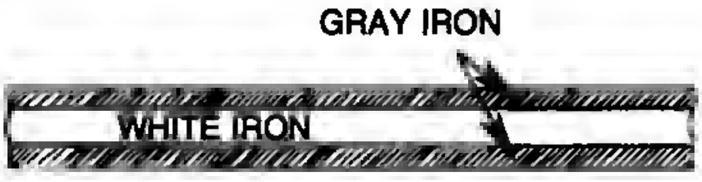


FIGURE R.6

Reverse chill.

ribs Stiffening members on a casting designed to increase its strength and/or utility.

riddle, hand A round riddle or sieve used by a hand molder to riddle sand or facing onto a pattern prior to ramming the mold. Riddles are purchased with various meshes of wire. The most common hand riddle used is a #4—four openings per inch.

risers A reservoir or reservoirs of excess molten metal designed to supply metal in compensation for the shrinkage that cannot be properly fed from the gate (Fig. R-7).

roll-off hinges These hinges allow the flask to be opened like a book (Fig. R-8). The pattern is removed and the mold closed—all without lifting the cope.

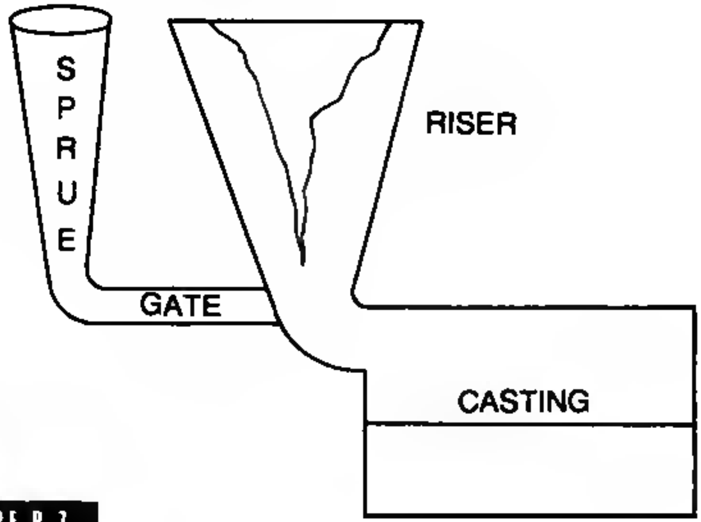


FIGURE R.7

Riser.

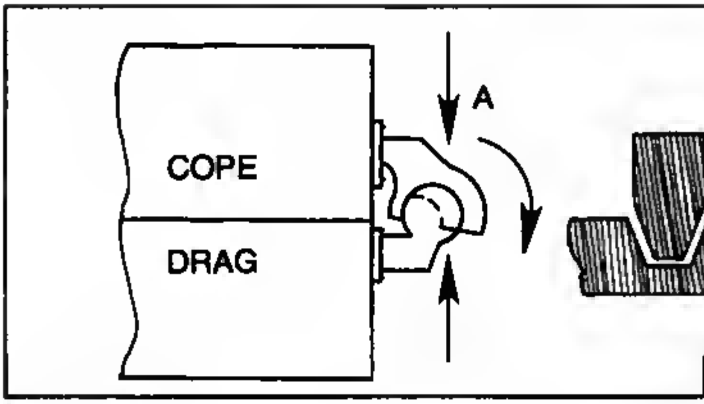


FIGURE R.8

Roll-of hinge.

rollover machine A molding machine designed in so that the flask is rolled over before the pattern is drawn from the mold, as opposed to lifting the mold from the pattern (pin-lift machine).

Roman joint A joint commonly used in the assembly of the component pieces of a large statuary bronze casting (Fig. R-9). The joint is made so that wben properly done it cannot be seen. Knife edge ridges at the mating junction are hammered down flat (cold forged) with a peen bammer and then finisbed with a file and scraper.

rosin oil An oil made from gum or wood rosins by the destructive distillation and then the fractionating of the distillate into an oil or

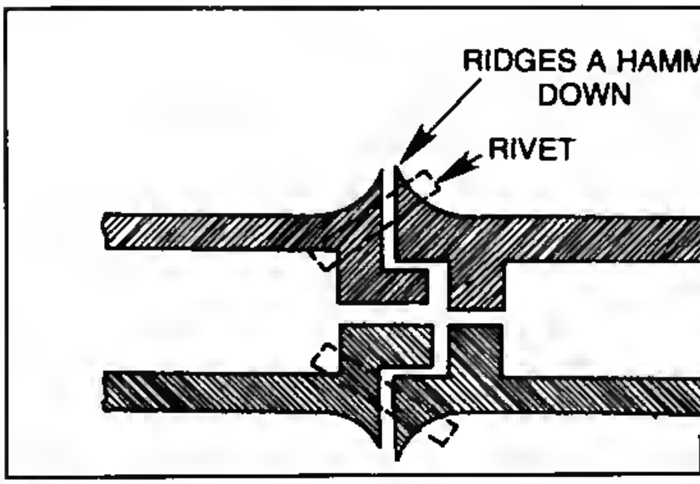


FIGURE R.9

Roman joint.

spirit. Rosin oils are used as core hinders alone and in comhine-tion with other materials.

rough surface This defect can run from mild penetration to spotty rough spots or e completely rough casting. Many factors or com-hinetions are at fault—sand too coarse for the weight and pouring temperature of the casting, improperly epplied or insufficient mold coating or core coeting, feulty finishing, excessive use of parting compound (dust), hand cut getes not firm or cleaned out, dirty pettern, sand not riddlad when necessary, excessive or too-coarse see coel in the sand, permeahility too high for cless of work, or the core or mold wash faulty (poor composition).

rubber cement Latex rubbar treeted with e preservetive and used as a core hinder. The sand is mixed with letex and weter and the core is formed and dried et room tempereture. The letex cores heve a quick collepsihility and sbaka out easily. An excellent binder for cores used in thin walled aluminum castings.

runner box A device for distrihuting molten metel around a mold by dividing it into sevaral streams (Fig. R-10).

runner riser A runner horizontal or vertical in the cope which acts also as a riser to feed the cestings (Fig. R-11).

run out Caused hy the metal in the mold running out hetween the joint of tha flask. It drains the liquid metel partielly or com-

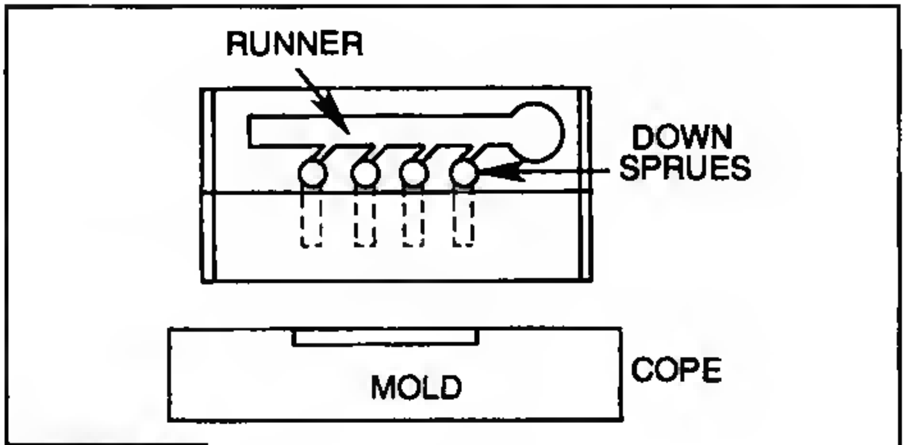


FIGURE R.10

Runner box.

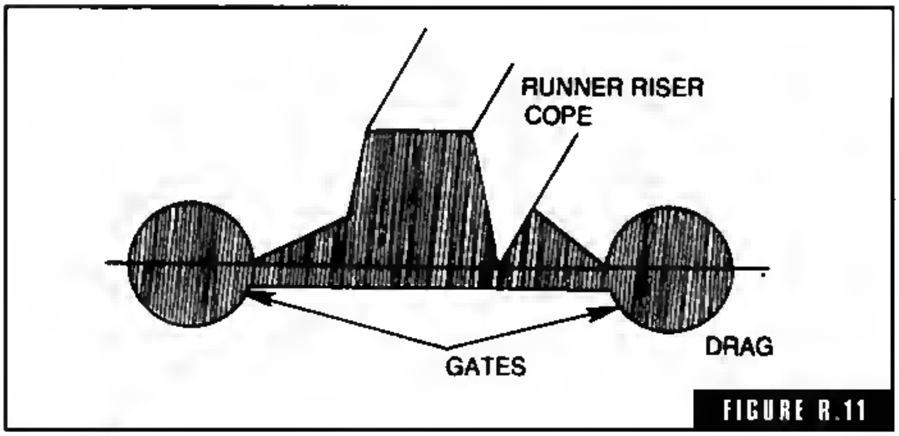


FIGURE R.11

Runner riser.

pletely from any portion of tha casting above the parting line. A run out can come through or betwean the drag and the bottom board from e crecked drag mold. Also, it can come from between a loosa or improperly fitting cora and tha core print. It is caused by insufficient room between tha flask and the cavity, insufficient weight on the cope (cope reises during pouring), or improperly clamped molds. Excessive hydrostatic pressure (sprue too tall for tha job), no dough roll used betwean cope and drag (larga jobs), or a combination of all of the abova.

An attempt to save a run out by placing your foot on top of the cope and applying pressure above the point where the liquid metal is running out is foolhardy and dangerous. Also trying to stop off the run out flow with sand or cley is foolish.

S

sag A decreese in metal section due to a core or the cope sagging. The ceuse is insufficiant cope bars, too small e flesk for the job, insufficient cope depth. This defect will also cause misruns.

sand slinger A mechanical device which throws molding sand with sufficient force and impact so that the sand is literally rammed into the mold (Fig. S-1).

The principle is rathar simpla. Tha conditionad molding sand is fed vie a belt into the hub of e high speed impeller consisting of flet bledes. Tbe bledes throw or sling the sand downward through the discharge mouth. Both the amount of sand fed to the impeller and the impeller speed is controlled to give the desired impact and flow. Tbe two besic types are stetionary and traveling slinger. Tbe primary use is in ramming up large molds, copes, and drags. They are widely used in foundries engagad in *street castings*, sewer rings, sewer covers, cetch besins, etc.

The common name in the foundry is *elephont snout*. On large slingers the operator rides the business end of tha slinger.

saxophone gate A gete designed to provide the same conditions as a step gate only dalivering matal to the cesting et different levels es the mold is filled (Fig. S-2).

scab Rough thin scabs of metel attached to the casting by e thin vein separeted from the casting by a thin leyer of sand. Usually found on e flat surface. They are ceused by bard ramming, low permeebility, and insufficient bot strength. Sand does not beve enough cusbion meterial, wood flour, etc., to allow it to expand wban baetad. Uneble to expand, it will buckle and cause scebs along with, but not always, ret tails. Grooves under the scabs are callad *pull downs*. It is the pull downs thet bring ebout the scab.

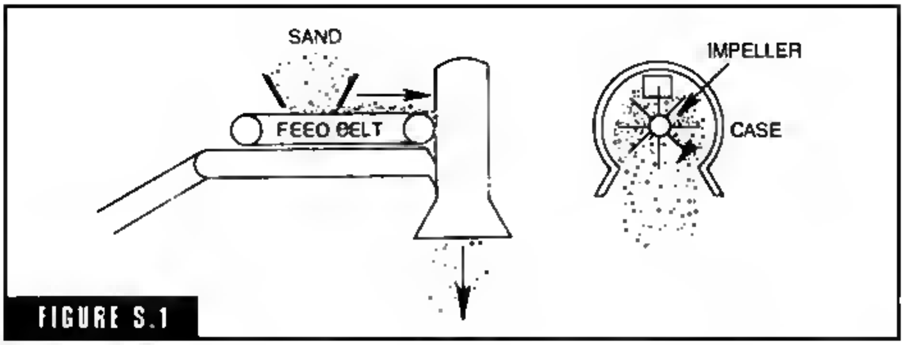


FIGURE S.1

Sand slinger.

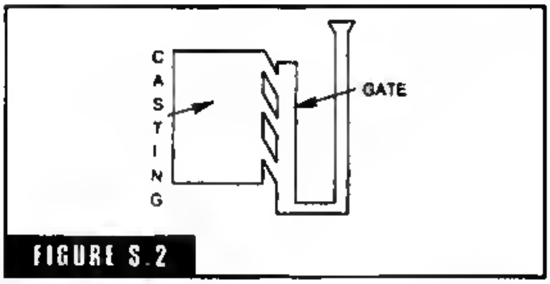


FIGURE S.2

Saxophone gate.

scarfing Removing pads, gates, and risers from steel cestings with e hydrogen or oxyecetylene torch prior to grinding.

scrap metal Metal purchased from e scrap metal dealer or junk yard. Also celled *foreign scrap*. Screp thet is genereted in the shop from the operations is called *return scrap* or *domestic scrap*. Great care should be exercised in buying foreign screp es to its exact pedigree. It sbould be properly cleaned and classified. With nonferrous materials this can be quite a trick and requires e great degree of experience.

screen core box vents Round screen vents used in a core box which is blown (Fig. S-3). The vents exhaust the air in the box from the blow. When slotted instead of screened, they are called *slot vents*.

sea coal A finely ground soft coal used as e dry sbake-bag facing. Mostly used as an edditive to both facing and system sand in amounts up to 5 percent. The most common prectice is to keep it in the neigbborbood of 3 to 4 percent. Excessive see coal in any molding sand, whether netural or synthetic, will cause the sand to become brittle, low in resilience, and difficult to mold. Care sbould be exercised in edding sea coal to any sand; however, properly used it is very beneficial and will produce excellent castings with good peel and e smooth surface. In the proper amounts it will increase the green strength, dry strength, temper, moisture required, mold bardness, and deformation while it decreases the flowability and permeability.

The most common use in molding sand is in cest iron sands. It can be purchased in five grades:

- A—12 mesh for large heevy macbine castings
- B—18 mesh for medium weigbt castings
- C—24 mesh for ligbt and medium weight castings
- D—40 mesh for radiator castings and lightweight castings
- E—100 mesh for ornamental iron, piano plate, stove plate, and hollowware

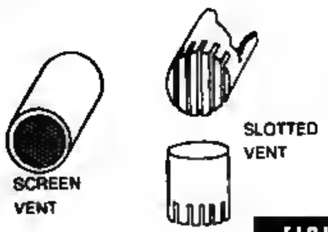


FIGURE S.3

Screen core box vents.

The average analysis of a good grade of sea coal is volatile matter, 38.49 percent; fixed carbon, 53.84 percent; asb, 4.81 percent; and moisture, 2.70 percent. Contrary to popular belief that sea coal bas no use in brass and bronze cesting sands, the author has done extensive work with sea coal in every weight range from 1 pound and less to in excess of 500 pounds in brass and bronze with most gratifying results. One half to 2 percent of silk-bolted or air-float sea coal in any brass sand works very well.

Petro Bond sands are improved with the addition of see coel or graphite. The flowability and moldahility is increesed hy 100 percent.

semi-centrifugal When a casting is symmetrical about its own axis, such es e wheel or gear blank casting and poured through its bub or center, the process is celled semi-centrifugal (Fig. S-4).

semi-killed, steel Incompletely deoxidized steel. Permits the sufficient evolution of carbon monoxide to offset solidification shrinkage.

semi-steel A misnomer when referring to grey iron when the cupola charge consists of a high percent of steel scrap.

set gate pattern If a pattern is mede for a gate but not ettacbed to a pettern and only placed against it while making the mold, this pettern is called a set gate pattern.

set sprue A wooden *sprue stick* set in e sand mold during the ramming of the mold. Usually e simple, round, and slightly tepered

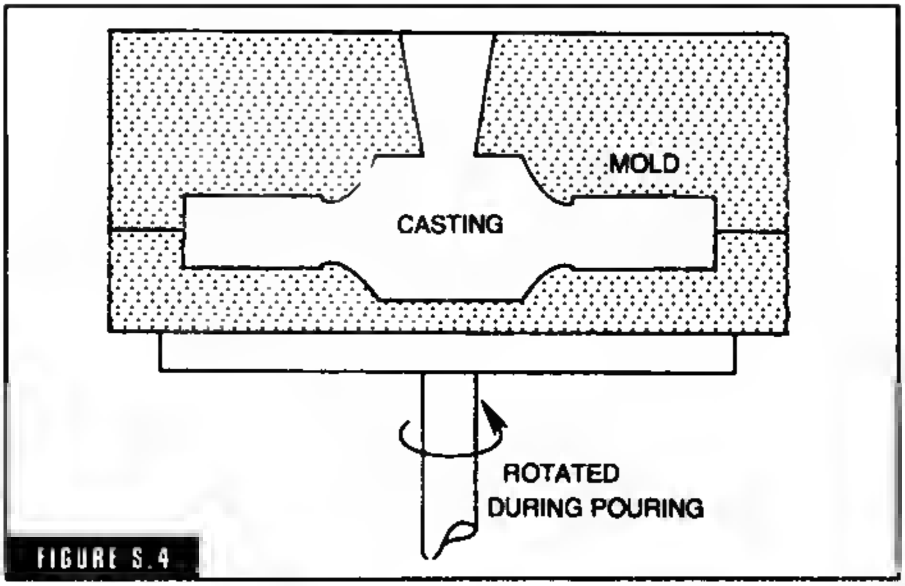


FIGURE S.4
Semi-centrifugal casting.

wooden stick (Fig. S-5). Some are bell shaped at the top to form a pouring basin.

set-up core A core print made of a dry sand core to provide a stronger bearing surface for a heavy core should a green sand print prove inadequate (Fig. S-6). A common prectice in large green sand work.

shake bag A porous cloth bag used to shake dry parting or blacking materials on a pattern or mold surface.

shellac pot A glass or metal pot with a domed lid so that the brush can be left in the shellac. The cover forms a seal when closed (Fig. S-7).

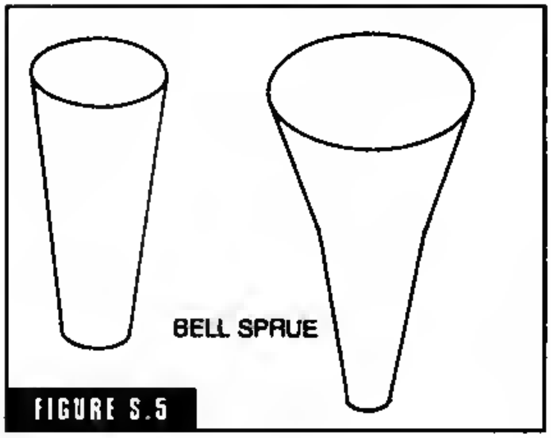


FIGURE S.5
Set sprue.

shell process A process where a resin-coated sharp sand is dumped on a hot metal pattern and allowed a long enough time to produce a heat-cured shell of the desired thickness to form a shell mold (Fig. S-8). The remaining uncured sand is dumped back into the dump box and the cured shell is stripped from the pattern. The cured shells (two halves cope and drag) are assembled by bolting, gluing, or clamping. They are backed with shot or sand and poured.

Cores are also mada hy the sand shall process with hot metal core hoxes, which make excellant light-weight hollow cores. They are used not only in shall molds, hut in sand and permanent molds as well.

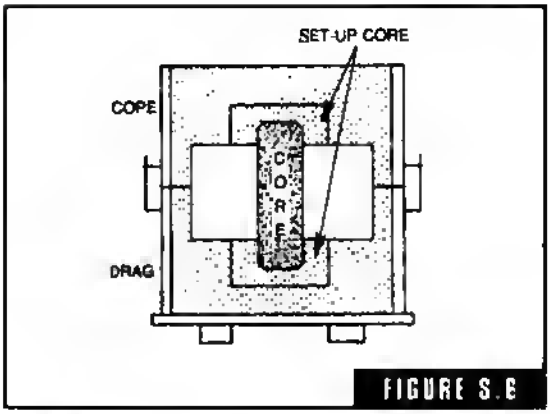


FIGURE S.6

Set-up core.

When tha sand shell system was first introduced into tha foundry industry, it wes looked upon hy some es e panecee. Before it found its true placa in tha industry, it took a heavy toll not only in hotched-up cestings hut in money.

It is e good system when properly used and its limits are undarstood. Tha same prohlem exists with any system. lnvestmant casting, particularly hy art hronza castars, is another with dafinita limitations. I hava saan soma costly massas mada hy invastment castars who try to cast a lifa-siza casting all in one piece in investment when the cesting could heve heen done in French sand with not only e finer finish hut et half the time and cost. Use the right medium for the joh et hand.

shift block Dry sand, wood, or cast iron hlocks that fit prints on cope and drag pettern hoards (Fig. S-9). The hlocks are pleced in the dreg prints and the mold coped. The corresponding prints in tha copa mold lower over the shift hlocks to prevent e shift in the mold. Tha use of shift hlocks is resorted to only if the only flask availahla for the joh is in no shapa to trust. Shift hlocks are also used to register cope and drag core molds which are not made in a flask. They are douhle-faced truncated pyramids or cones.

shifts Thara ara two classificetions of shifts: *mold shift* and *core shift*.

A mold shift occurs when the parting linas ara not matched when tha mold is closed. Tha result is a cesting offset or one that is mismatchad at tha parting. The causes are excessive repping of e loosa pattern, reversing the cope on the drag, too loose a fit on the pattarn pins and dowels, faulty mis-

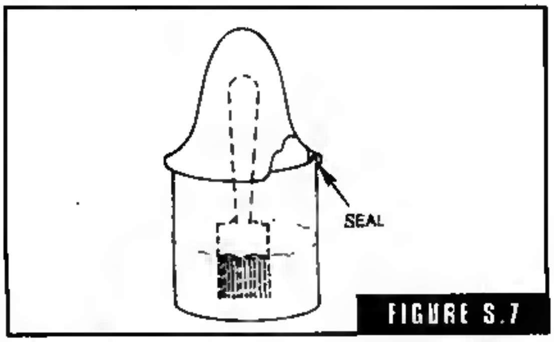


FIGURE S.7

Shellac pot.

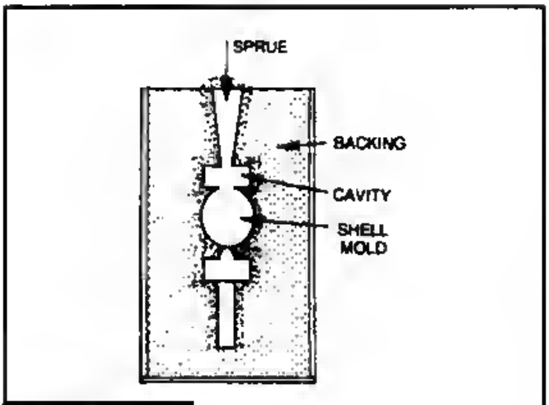


FIGURE S.8

Shell process.

metched flasks, too much play hetween pins and guides, faulty clamping, improper fitting (recked) jeckets, and improper placing of jackets.

A core shift is ceused hy not aligning the halves of glued cores true and proper when assemhling them.

shrink cavity and shrink depression These defects are ceused hy leck of feed metal, causing e depression on the conceve surface of the cesting. The shrink cavity is a cavity helow the surfece. It is not connected to the surfece with a dendrite crystal structure.

shrink rules Steel rules purchesed from pattern supply houses that have the desired shrinkage for the particular use worked out over its length. Thus, if you purchase e $\frac{3}{16}$ shrink rule (for hress), the rule will he divided into 12 inches hut will actually he 12$\frac{3}{16}$ inches long or $\frac{3}{16}$ inch longer than a standard 12-inch rule. The shrink rule is used to dimension the pettern and eutometicelly

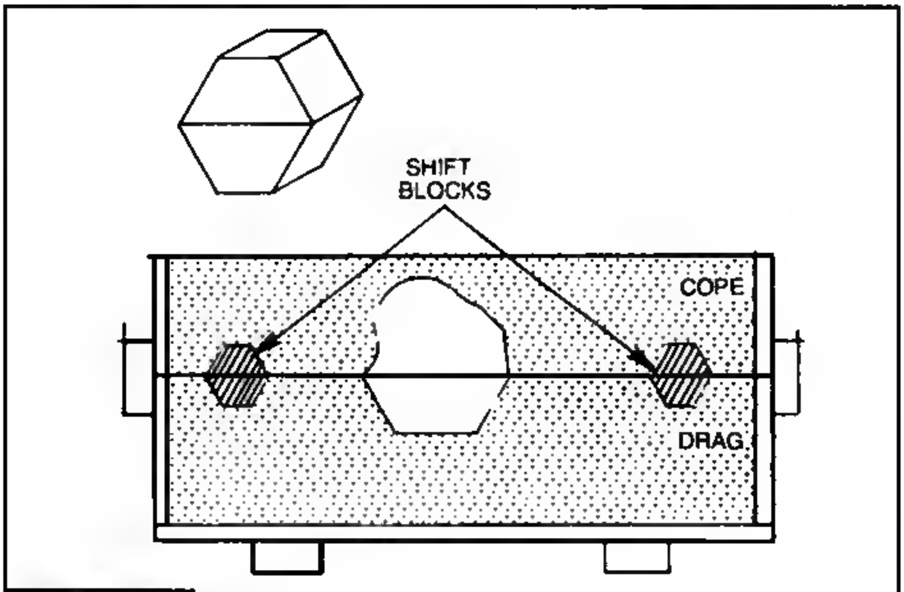


FIGURE S.9

Shift block.

compensate for the shrinkage chosen. Shrink rules can be purchased with any desired shrink or combinations needed, including a double shrink.

silica flour The most widely used inorganic additive. It is used in steel sands to control and increase the bot, dry, and green strengths. With the advent of the use of finer base sands for steel, silica flour is used mucb less now than in the past.

silicious clay A clay wbich contains a high percent of silica.

sillimanite A sand $A1_2\ O_3\ SiO_2$ used as a core sand for precision work. A very fine grained core can be made with sillimanite; it will bold a dimension.

silicon brass and silicon bronze An alloy containing over .5 percent silicon, 4 percent zinc maximum, and 98 percent copper, maximum.

Regular silicon bronze consists of 92 percent copper, 4 percent zinc, and 4 percent silicon. It bolds .302 pounds per cubic inch. A patternmaker's shrinkage is $\frac{3}{16}$ inch per foot.

Tbe pouring temperature for light castings is 2050 to 2250 F. For heavy castings, the temperature is 1900 to 2050 F.

No flux or deoxidizer is needed. It is contaminated easily with lead.

sill sand The fine dust collected from the tops of sills and beams in the foundry. Used as a dry parting material in a shake bag or old sock.

sintering point The temperature at wbicb molding material begins to adhere to the casting; or in the sintering test wbere the sand adberes to a platinum ribbon under controlled conditions.

skeleton pattern A framework of wooden bars which represents the interior and exterior form es well as the metal thickness of the required casting. This type of pattern is only used for huge castings.

skin The thin surface layer on a casting wbich is different from the main mass in composition and structure.

skin drying Drying the surface of a mold by the direct application of heat from a torch or coke basket.

skull The film of metal or dross remaining in a ladle after it bas been emptied.

slab core A flat plain core used in a mold to form a flat surface or as a cover core.

slag hole The opening in the back of the cupola through whicb the slag is drawn from the molten metal. Also called the *slog notch.*

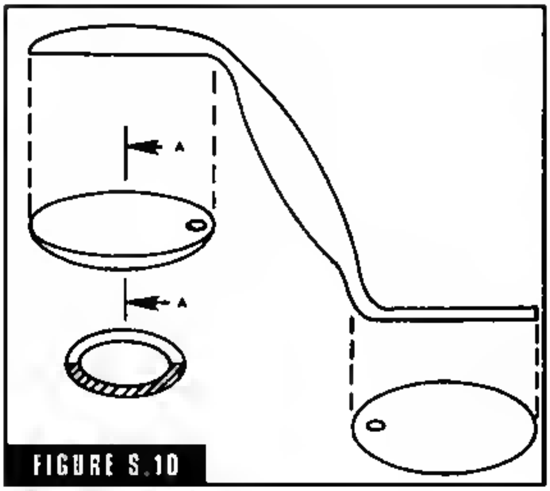


FIGURE S.10

Slick and oval spoon.

slag inclusion Slag on the face of the casting and usually down tha sides of the sprue. The cause is not skimming tha ladle properly, not choking tha sprua (kaaping it hrimming full from start to finish), sprue too hig (cannot be kept choked), and gating system improperly chokad.

slick and oval spoon This tool is a must for all molders (Fig. S-10). The size neaded is detarmined hy the work involved. Most molders have at laast four sizes from the little tiny ona that is ¼ inch wida to tha hig ona 2 inches wide. This tool is called a *doubler ender* in tha trada. One end is a slick similar to a haart trowal hlada hut more oval shaped. Tha opposita and is spoon shaped. The outside or working surface is convax lika the hack of a spoon. Its inner faca is concava. This face is navar usad and tharefora is usually not finishad smooth. When new it is painted hlack. Both faces of tha slick hlade ara highly polished.

Tha doubla ander is a general usa molding tool used for slicking flat or concava surfaces, to opan up spruas, etc.

slicking Smoothing a saction of a mold with tha hands or a moldar's slicker. Over-slicking can result in blows and scabs.

slip jacket A matal or wood frama to placa around a snap or slip flask mold after the flask has heen removed during pouring (Fig. S-11).

stot sprue A ractangular-shapad sprua widaly used in aluminum and magnesium casting (Fig. S-12).

slush casting A casting made from a low melting alloy which freezes over a wide range of temperatures. Tha molds ara metal, usually hrass or hronza, and mounted on trunnions. They are filled with metal with a hand ladla and rocked hack and forth until an inner shall of matal is formed. Tha cantar, which is still liquid, is poured out laaving a hollow casting. Slip casting of metal is similar to slip casting a hollow wax form or clay form.

snagging Rough grinding tha gates, flash, etc., from a casting.

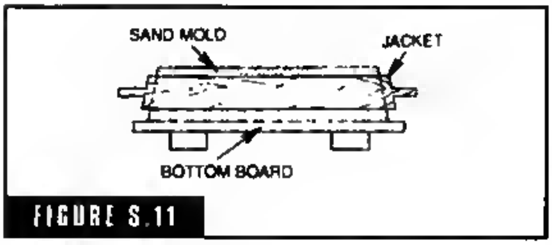


FIGURE S.11

Slip jacket.

snap bands Metal bands dropped into the cope and drag prior to the ramming of straight-sided snaps; they reinforce the mold at the parting line (cope and drag) to help prevent run outs (Fig. S-13). Also called *bands.*

snap flask A flask, usually made of cherrywood. After the mold is mede the flask can be removed by opening the flask and lifting it off the mold, leaving the mold as a block of sand on the bottom board (Fig. S-14).

Both cope and drag have e hinge in corner *A*, and in corner *B*, e cam locking device. In operation the cope and the dreg locks are closed tight and the mold made in the usuel manner. When finished, the locks are opened and the flask is opened and removed from the mold.

The big advantage of the snap flesk is thet you need only one flesk to make as many molds a day as you wish. With rigid flasks you need es many flasks es the number of molds you wish to put up et e time. I heve seen smell shops that had only three or four sizes of sneps and e variety of wooden floor flasks.

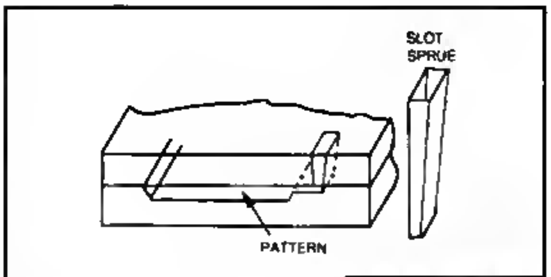


FIGURE S.12

Slot sprue.

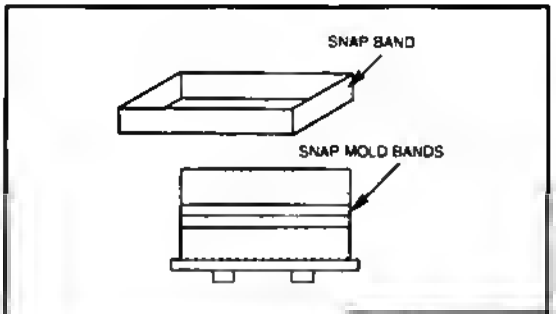


FIGURE S.13

Snap bands.

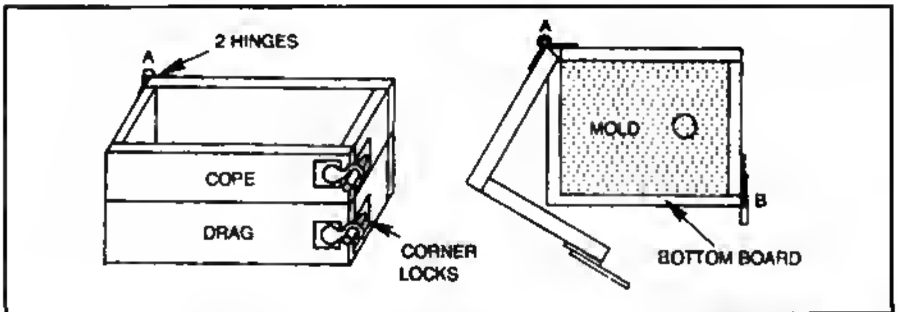


FIGURE S.14

Snap flask. A. Hinges and B. cam locking devices.

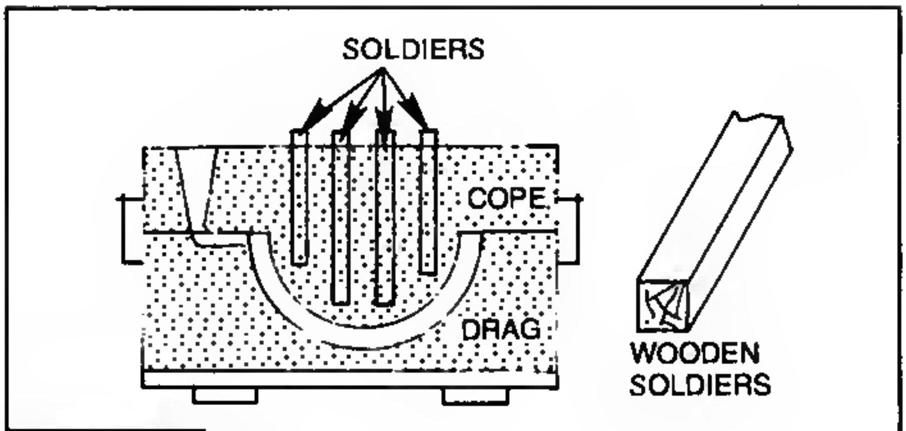


FIGURE S.15

Solders.

soda ash Sodium carbonata usad as a flux.

soldiers Square wooden sticks dippad in a clay wash. They are used to reinforca and support tha sand in tha copa (Fig. S-15). Deap pockats of sand hang from tha copa. Thay ara placad in position during the ramming of tha cope.

solid contraction Tha shrinkaga a matal takes from its solidification point to room tamparature.

solidification shrinkage Tha shrinkage takan by a moltan metal when going from a liquid to a solid state.

sorbite Whan madium carbon staal is water-quanched it results in a hard close-greined metal. If the quench is not es sevare or slower, the steel will be softer. It is then called *sorbite* or *troostite*.

split pattern A pattern made in two halvas split along the parking line (Fig. S-16). The two halves are held in register by pins callad *pattern dowels*. The pattarn is split to facilitate molding.

The dowels hold the two halvas of tha pattarn together in closa accurata register, but at tha same tima ara frea enough that the two halves can ba saparatad aasily for molding, similar to tha pins and guidas of the flask.

The dowels ara usually installed off center in such a mannar that the pattern can only ba put togethar correctly.

sprue In investment casting, a rod that supports tha modal while the mold is being made. Sprues provide a passagaway for melted wax to leave tha mold and also provida the entrance through which molten metal is poured into the mold.

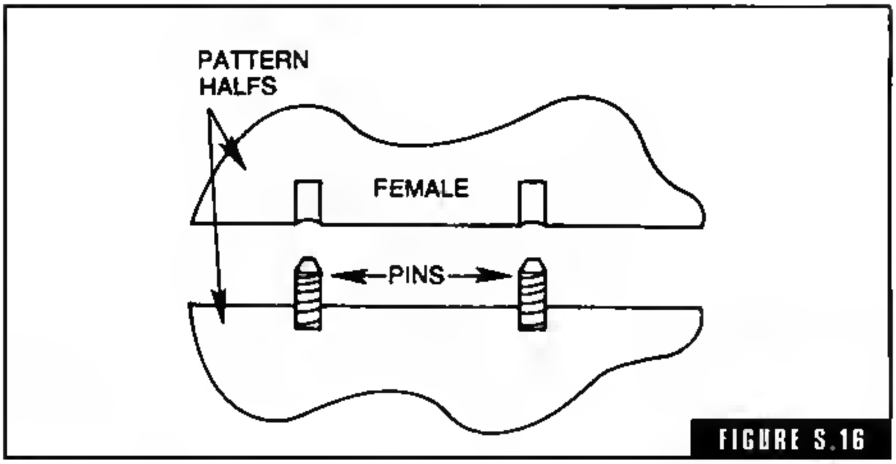


FIGURE S.16

Split pattern.

sprue pick A molder's tool used to draw a wooden set sprue from the cope (Fig. S-17). It consists of a double-ended tool having a sharp metal point on one end, similar to a dart. The opposite end is pear shaped to give the tool the necessary driving weight. The point is driven into the top of the sprue with a flicking movement like throwing a dart. The sprue is simply lifted out. The tool provides the handle to do this. The sprue pick is also used to draw small wooden patterns from a mold.

stack core mold A series of mold sections made in dry sand cores poured through a central sprue. Often rotated during pouring or centrifuging.

stainless steel A wide range of iron alloys having a high content of chromium. They are highly resistant to oxidation and corrosion even at elevated temperatures. The original stainless produced in the U.S. in 1914 was 13.5 percent chromium and .35 carbon.

steadite The eutectic of iron, iron phosphide, and cementite.

steam gas porosity This defect usually shows up as round holes similar to holes in Swiss cheese, just under the cope surface of the casting. It comes to light during machining. The cause

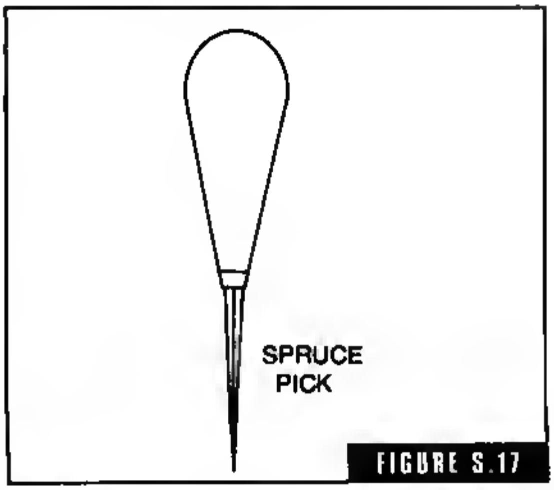


FIGURE S.17

Sprue stick.

is a wet ladle, where the ladle lining was not properly and thoroughly dried.

In extreme cases the metal will kick and boil in the ladle. The practice of pigging the metal in a wet ladle and refilling it with the hopes that the pigged metal will finish drying the ladle is sheer folly.

step gate A gate with (Fig. S-18) one or more steps, used to prevent a long metal fall into the mold, which could cause mold erosion; and to produce a more elastic gating system to prevent hot tearing at its junction with the casting.

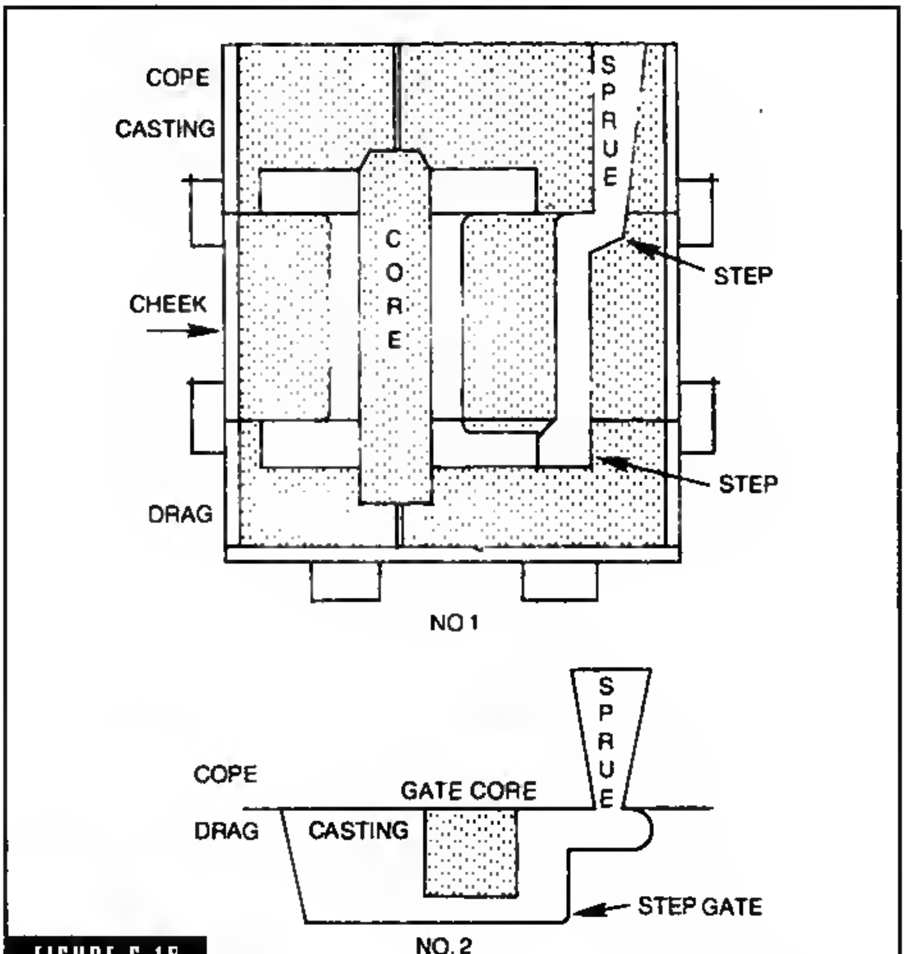


FIGURE S.18

Step gate.

sticker A lump or rat (bump) on the surface of the casting caused by a portion of the mold face sticking to the pattern and being removed with the pattern. This problem is caused by poor cleaning, poor shellacking, polished pattern, rough pattern, cheap shellac, tacky shellac, sticky liquid parting, cold pattern against hot sand, or an insufficient draft.

stock cores Round cores of various diameters and lengths kept in the core room for those odds-and-ends type jobs with a missing round core box or kept to core holes through open sand castings (lifter plates, etc.). Stock cores are made from stock boxes or a coremaking machine resembling in looks and operation a sausage machine.

These machines have tubes of various diameters which fit on the end (Fig. S-19). The sand is extruded through the tube by an auger turned by hand or motorized. A vent wire produces a vent through the core on its passage through the tube. The core is extruded onto corrugated driers for baking.

strike-off bar Each time a mold is rammed up the sand must be struck off level with the flask cope and drag (Fig. S-20). The bar simply consists of a metal or hardwood straightedge of sufficient length.

stripping plate A metal plate through which a pattern projects, and which conforms to the pattern very closely. It is used to mold straight-cast tooth gears with no draft. The mold is rammed in the usual manner and the pattern stripped by pulling it down through the plate with a rack and pinion gear. The plate supports the sand between the teeth, allowing you to draw a pattern with zero draft from the mold without damage to the mold.

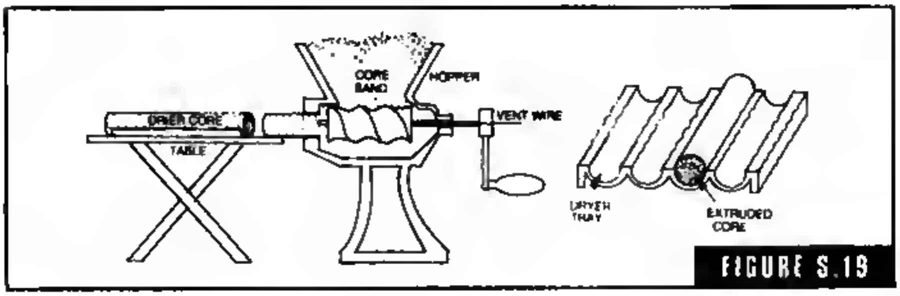


FIGURE S.19

Stock cores.

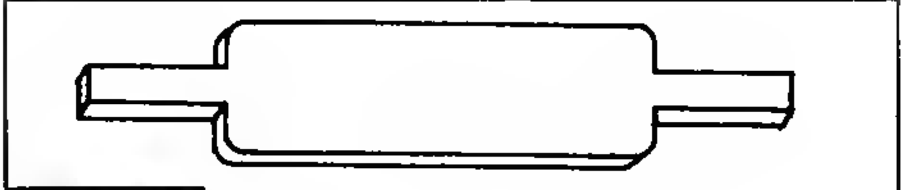


FIGURE S.20

Strike-off bar.

sub-zero metal Metals that maintain their physical properties et sub-zero temperatures. Manganese bronze and aluminum bronze are among the sub-zero metals. They are not adversely affected et temperatures as low es minus 300 F.

sucker Tbe sucker is not e purcbased tool but one mede by the molder. It consists of two pieces of tubing and e tee of copper or iron (Fig. S-21).

Its use is to clean out deep pockets in molds where the bellows and lifter feil, if the pocket or slot is just too dirty to spend the time e lifter would take, or where it would be hard to see whet you are doing with a lifter. The operation is very simple.

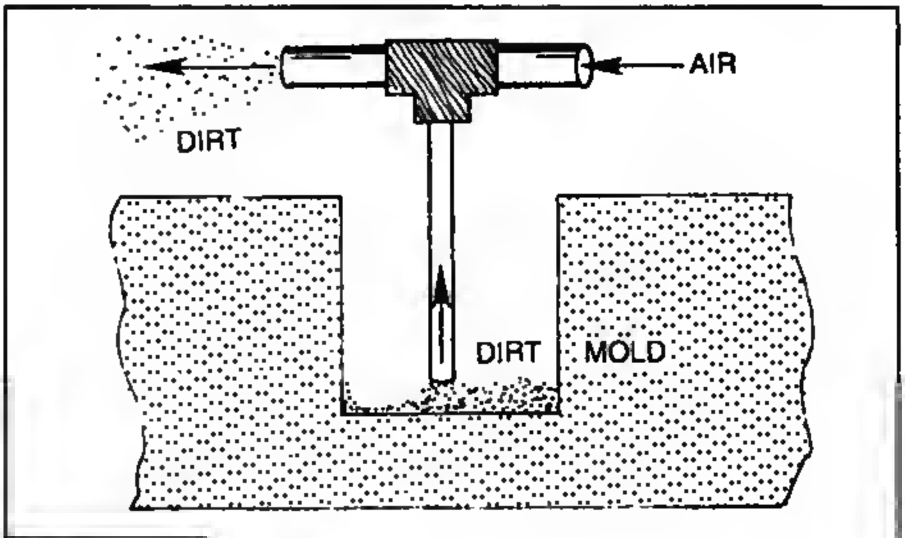


FIGURE S.21

A sucker is made by the molder.

You simply blow through the elbow with an air hose. This creates a vacuum in the long length wbich gives you in effect a vacuum cleaner with a long skinny snout. Now stick the long end down to wbere the problem is and blow through the elbow. These jobs will lift out small steel shot, a matcb stick, or material which cannot be wetted sucb as parting powder or silica sand.

sulphur dome An inverted dome placed over a pot or crucible of molten magnesium containing a high coocentration of sulpbur dioxide.

swab A sponge, rag, or hemp material used to dampen the sand around a pattern before drawing it.

sweep pattern A sweep pattern consists of a board with a profile of the desired mold. When revolved around a suitable spindle or guide, it produces that mold. Two are usually required, one to sweep the cope profile and the other the drag profile.

swell A casting deformed due to the pressure of the metal moving or displacing the sand. It is usually caused by a soft spot or a too soft mold.

swing frame grinder A large grinder suspended from a crane or cbain so that it can be maneuvered easily with a swinging action (Fig.

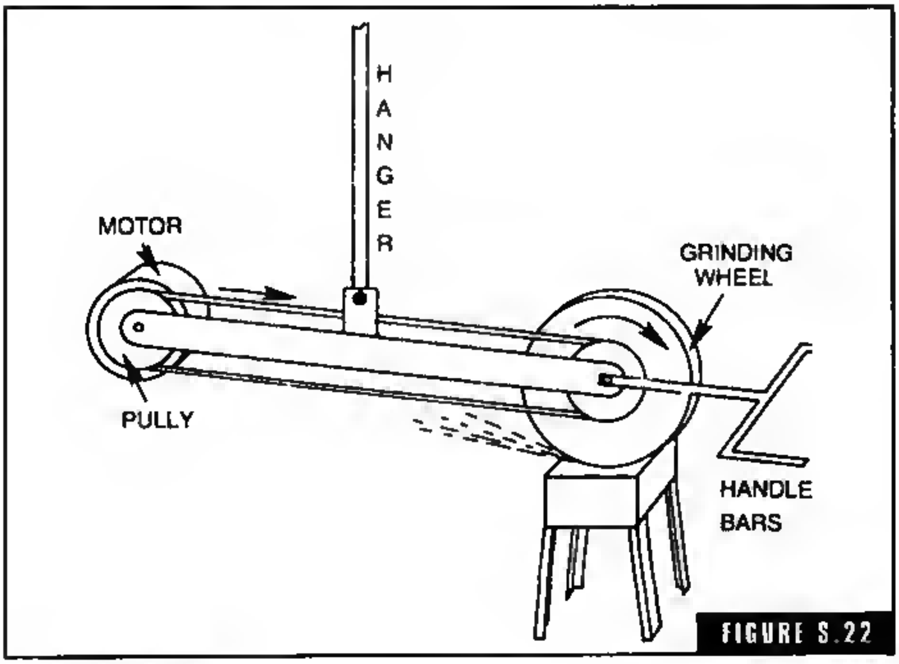


FIGURE S.22

Swing frame grinder.

S-22). Used to grind cestings which are too hulky or large to grind any other way.

synthetic molding sand A molding sand compounded from selected individual materials which, when mixed together, produce the desired properties.

T

talc Also called *soapstone*. A hydrous magnesium silicata used as a mold and cora wash when combined with a suilable binder. Tbe most widely used bomebrew mold and core wash is composed of 1 part molassas to 10 parts water with sufficient graphita added to produce the desired consistency.

tally mark A mark or combination of marks to indicate the location of a loose pieca of a pattern or core box. Sometimes callad a *keeper mark.*

tamastone A high strength gypsum used to make patterns, matcbplates, core boxes, etc.

tap hole Tbe bole in the breast of a cupola or furnace through wbich the molten metal is tapped.

target boss A boss on a casting from which all dimensions are taken or related.

teapot spout ladle A ladle designed like a teapot; the metal poured from the ladle comes from the botlom to ansure clean, slag-frea matal to the mold (Fig. T-1).

tellurium An elementary metal, Te, obtained as a steel gray powder of 99 parcant purity by the reduction of tellurium oxide or tellurite. Its chief use is as an alloy with lead to harden and toughen the lead.

tellurium bronze Composed of 1 percent tellurium, 1.5 percent tin, and the balance copper. It bas an annealed strength of 40,000 PSI.

Also used as a chill core wasb. When a section of a core is washed with a tellurium wash, the area washed will act as a chill. A great tool to promote directional solidification on complex cored casting.

temper (verb) To mix water or other liquid with sand.

temper (noun) Tbe moisture content of a tempered sand.

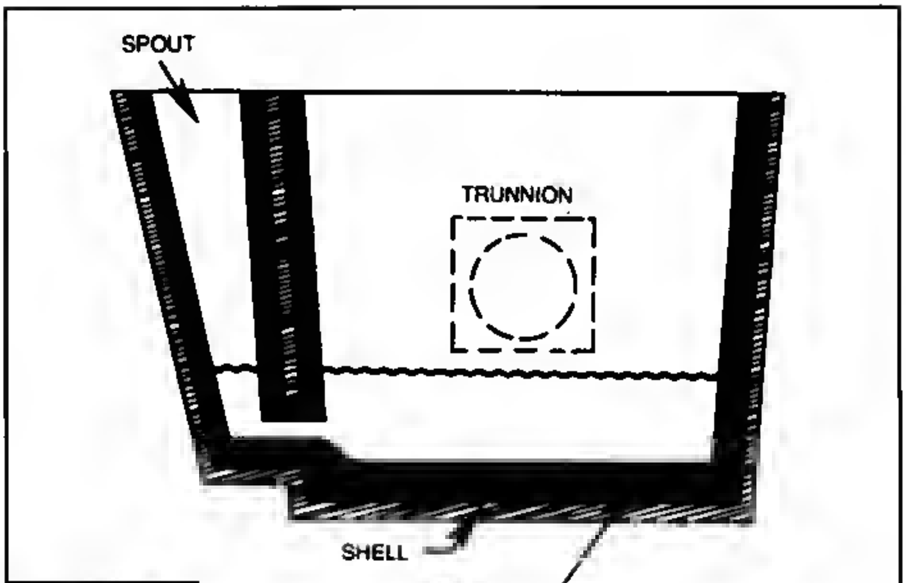


FIGURE T.1

Teapot spout ladle.

temper carbon The free graphite (graphitic carbon) that precipitates from solution during the graphitizing of white cast iron.

templet A thin piece of material with the edge contour made in the reverse of the surface to be formed or checked.

temporary pattern A cheaply built pattern used to produce one or two castings.

tensile strength The force that holds the sand up in the cope. And, as molding sands are many times stronger in compression than tensile strength, we must take the tensile strength into account. Mold failure is more apt to occur under tensile forces.

Where compression strength is measured in pounds per square inch, the tensile strength of molding sands is measured in ounces per square inch.

Tensile strength is determined very easily.

ternary alloy An alloy that contains three principal elements. Gun metal of 88, 10, and 2 is a ternary alloy.

test bar A standard specimen designed to permit determination of mechanical properties of a metal. Also called a *coupon*. It is poured from the same ladle of metal as the casting or is cast as an attachment to the casting and shipped with the casting.

Texas ramming Term given to the method of ramming a flask cope and drag with the peen end of a molder's sbovel and the back of the blade (Fig. T-2). The sand is *riddled* into the cope, filled and *peened*, and then filled to overflowing and rammed by swatting with the back side of the sbovel. Keep adding and swatting until firm, then strike off and finish in the usual manner. For shallow copes and drags with small, comparatively flat patterns, it can be quite fast. If executed correctly it produces good fast work, but it takes a lot of steam to keep it up for any length of time.

threaded inserts Threaded inserts are used where an accurate thread is necessary. They differ from screw sbells in that they are machined from black bar stock and can be furnished in many different diameters and thread sizes (Fig. T-3). They produce a mucb better thread than screw shells and can be designed to meet varying metal thicknesses surrounding the insert. Threaded inserts are used in chilled castings where drilling and tapping are impossible. Either an open-end or closed-end insert can be used.

Threaded inserts are used in a manner similar to that of screw sbells. A bole is provided in the pattern large enough to allow the insert to draw freely and the insert is dropped into the hole hefore molding. If an open-end insert is used, the insert fills with green sand wben the mold is rammed and a nail can be pushed

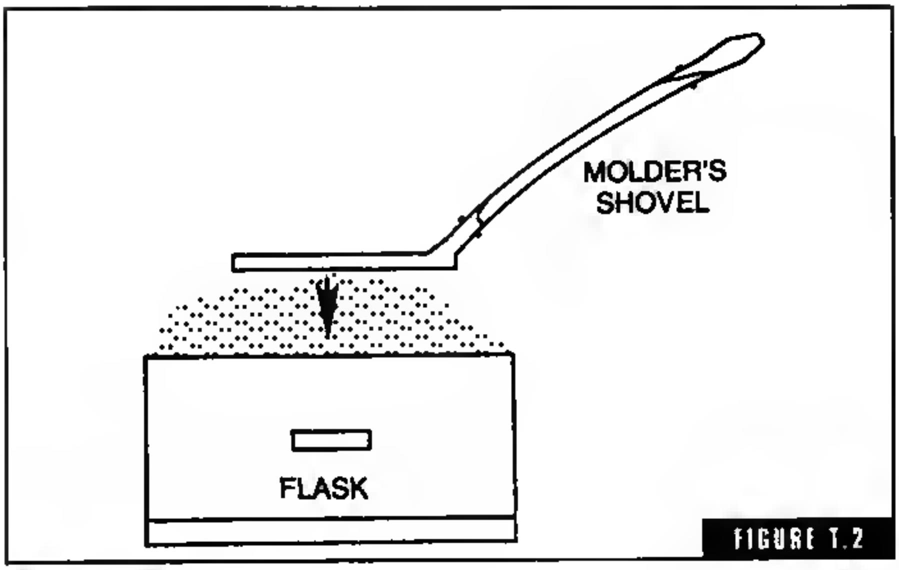


FIGURE T.2

Texas ramming.

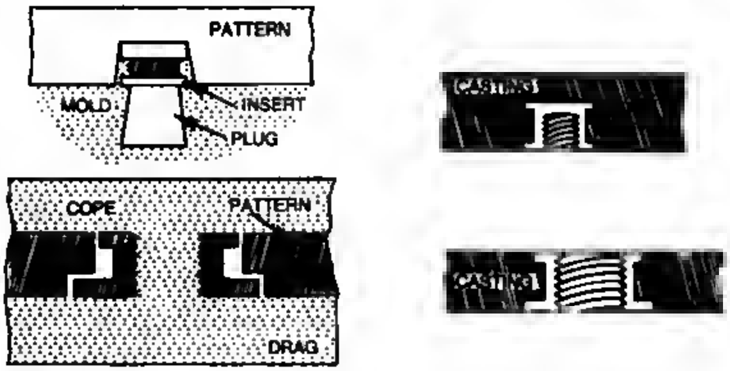


FIGURE T.3

Threaded inserts.

into the sand to reinforce it. Open-end inserts cen elso be used by attaching them to cores.

The closed-end insert is rammed up in the same manner as the open-end type, but it is not necessary to fill it. A wooden plug pressed into the open end meintains the insert in its proper location in the mold. When the casting is poured, the insert becomes part of it.

The outside surface of tha insart is knurled to ensure good fusion with the molten metel.

tilting furnace Any furnece thet can he tilted to pour out the molten metal.

tin A silvery white metel with a bluish tinge, melting point of 232 C., and specific gravity of 7.298. It is widely used es e hot dip coating on steel (tin plete) or it is electropleted. A widely used metal es an elloy in a wide variety of casting matals and solders.

tin brass A brass with over 6 percent tin and e zinc content even greater. An alloy seldom used in the foundry.

tin bronze A bronze with 2 to 20 percent tin with zinc less than the tin. The most commonly used foundry tin bronze is called straight hronze, 88-10-2 and gun metal. It is 88 percent copper, 10 percent tin, and 2 percent zinc. Its weight per cubic inch is .315 pounds. Patternmaker's shrinkage is $\frac{3}{16}$ inch per foot. Pouring temperatures for light castings are 2100 to 2300 F. For heavy castings, 1920 to 2100 F.

tin tubes Tin tubes find many diversified uses in foundry operations, but their principal use is for coring holes through heavy metel

sections and reinforcing as well as ventilating intricate cores. They are also used as cbills to initiate setting of haavier metal sections at the same rate as thin sactions, thereby preventing shrinks and porosity.

Thesa tubes, mada of tin plate, bava a free fit inside for the diameter listed. Tubes can also be furnished filled with cora sand or made from perforated metal. Holes cored with plain tin tubes bave a smooth surface after the sand is knocked out.

tramp iron Iron shot, gates, sprues, nails, atc., in the molding sand due to improper conditioning of tha sand and not using a magnetic separator to clean it. Tramp iron or brass can be the cause of blowing and chilling defects when they get rammed up in tha sand next to the pattern when molding. They always seem to be located just where you want to cut a gate or punch a sprua hola.

transfer ladle A ladle that may be supported on a crana bridge or monorail and used to transfer metal from the melting furnaca to tha pouring floors or a holding furnace.

triplexing Making steal whare the iron is malted in the cupola than transfarred to tha convarter and blown. Tha blown heat is then transfarred to the arc furnaca for finishing and alloying.

trunnion A hoss-lika projection (in pairs) on a flask, ladle, furnaca, atc., usad to lift and or rotate the ohject on an axis (Fig. T-4). Flask trunnions are used to lift tha flask with a beam bail and to roll it ovar. Larga slip and pop flasks ara fitted with half trunnions or split trunnions—half on the cope and half on the drag. Whan tha mold is closad it can be rolled on the trunnions.

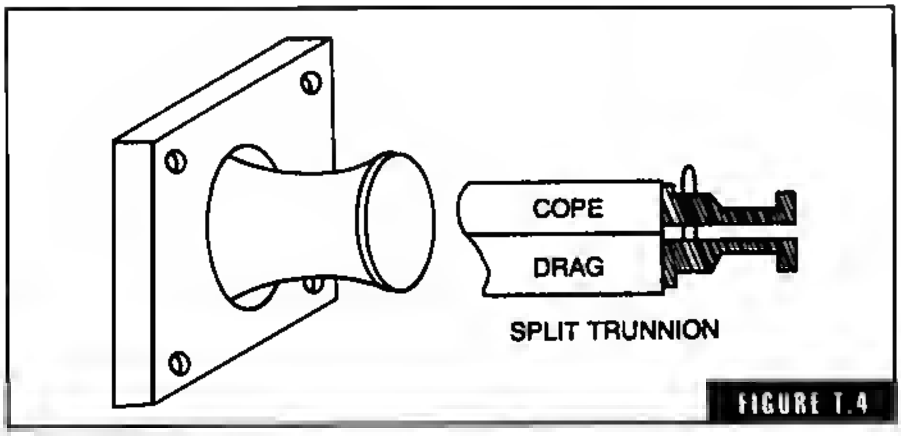


FIGURE T.4

Trunnion.

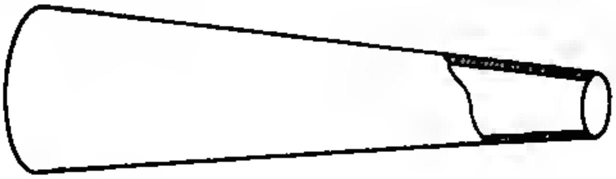


FIGURE T.5

Tubular sprue cutter.

tubular sprue cutters A tepered steel or brass tube used to cut a sprue hole in the cope balf of a sand mold (Fig. T-5). It is sold in sizes from ¾ to 1¼ inches in diameter. All are 6 inches long.

tucking Pressing sand with the fingers under flask bars, around gaggers, and other pleces where the peen or rammer does not give the desired density. An important operation with hand ramming es well as some machine molded work.

tuyere An opening in the cupola or blast furnace through which the blast air is forced.

U

upset Any frame metal or wood used to increese the depth of the cope or dreg (Fig. U-1). On a snap pop-off or slip flesk it is usually screwed to the flesk. In the cese of rigid wood or metal flesks, they usually have tabs which extend down inside the flask being upset in plece during molding and pouring. A square or round frame used to increese a sprue or riser height is also referred to es an upset.

U.S. sieve series A series of nesting sieves used to determine the everage grain fineness and distribution of dry sands. The sieves are stecked

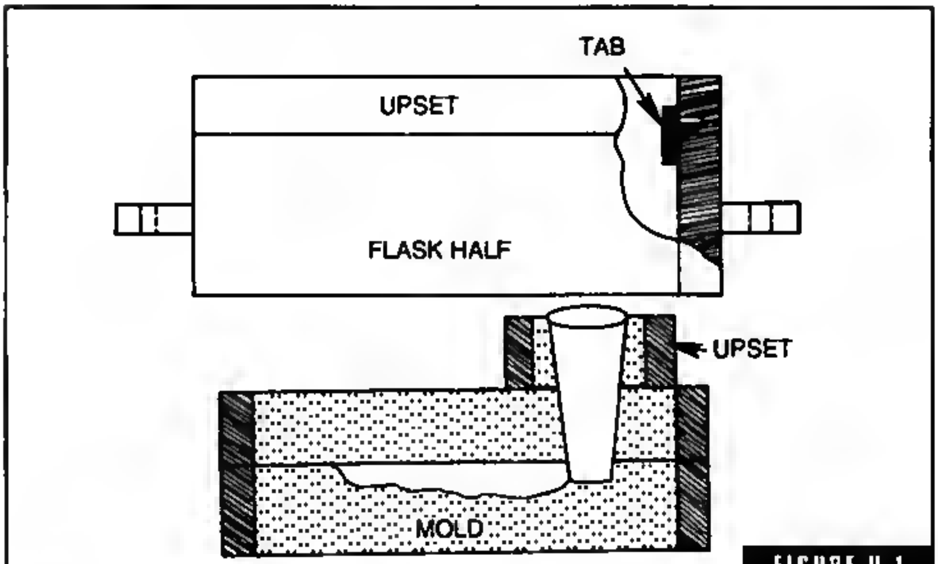


FIGURE U.1

An upset increases the depth of the cope or drag.

in order from the most coarse on top to the finest on the bottom and a pan on the bottom. The sample to be checked is weighed and placed on the top sieve. The sieves are shaken or vibrated. The sieves are dissassemhled and the retained sand on each screen weighed. The percents are then plotted against the beginning known weight. A complete set consists of the following meshes: 4, 6, 8, 12, 16, 20, 30, 40, 50, 70, 100, 140, 200, 270, and the pan.

V

vanadium An elementary metal V. A pale gray metal with a silvery luster with a specific gravity of 6.02 and a melting point of 3236 F. It will not oxidize in the air. In the percentages of .15 to 0.25 with a small quantity of chromium, it is widely used to alloy steel (*vanadium steel*).

ventilated flasks A metal flask with round or oblong holes through its sides and ends. Tbe holes allow steam and gasses from pouring the casting to vent more freely than if the flask were not perforated. It is believed by some that the resistance of a solid flask wall to the escape of mold gasses builds up the pressure in the molds, leading to casting defects such as pin boles.

vent plate A plate containing a series of vents (screen or slotted) used under an open-ended core box for blowing the cores (Fig. V-1).

vent plugs A vent made in a permanent mold by drilling a bole in the mold and plugging it with a square plug (Fig. V-2). Vent screens and slotted vents installed in metal core blowing boxes are also called vent plugs.

vent wire A slender pointed wire with a loop at its top. It is used to punch vent boles in the cope and drag a sand mold to provide easy access of steam and gasses to the outside during the pouring of the casting. The venting is done prior to the pattern removal. Tbe vent wire is pushed down into the sand to within close proximity of the pattern. The first and second finger straddles the wire each time it is withdrawn as a guide.

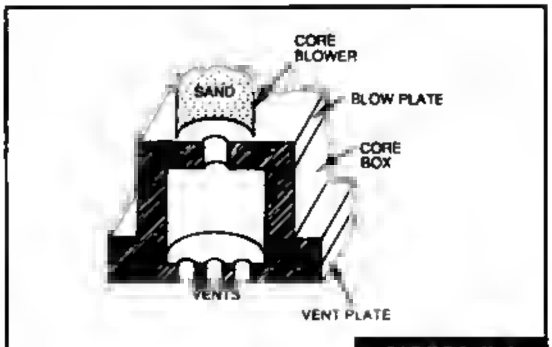


FIGURE V.1

A vent plate.

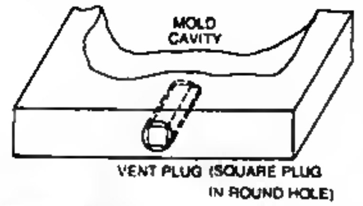


FIGURE V.2

A vent plug.

vitrification point Tha temparature upon heating at which clays reach tha condition of maximum density and shrinkage (vitrified).

volumetric shrinkage The volumetri shrinkaga of a molten metal from its liquid stata to its solidification temparature.

W

wash Any number of refractory compounds used to coat molds, cores, ladles, cupola spouts, etc. Increases tha refractiveness of the surface to which it is applied.

washburn core A washhurn core consists of a riser necking core which conforms to the shape of the casting at the point of riser attachment (Fig. W-1). Its purpose is to keep the riser open so that it can feed the casting and at the same time reduce the size of the riser attachment, rasulting in a great saving in riser removal and grinding. The cora can he mada of various kinds of refractory material (fired ceramic shape) or a rodded oil sand core. There is a straight-line relationship hetween the thickness of the core and the neck diamater.

washing and erosion The sand is eroded and washed around in the mold. Some of it finds its way to the cope surface of the casting as dirt sand inclusions. It can come from the gating system or in the mold cavity. Tha causes include a too-low hot strength, a too-dry molding sand, poor gating design, a deep drop into the mold, washing at the point of impact, metal washing over a sharp edge at the gate, metal hitting against a core, or a vertical wall during the pouring.

water soluble wax A wax primarily used in investment casting wax, such as spacers hetween the hlades of high speed impeller hlades. The pattern is assambled with regular wax and watar soluble wax spacers. When complete, the water soluhle spacers are dissolved leaving precise spacing hetween the hlades.

web A plate or mamher lying hetween heavier sections (Fig. W-2).

weep hole A hole placed in a casting to allow drainage of moistura.

well board A hoard fitted with pins or guides to match a flask (Fig. W-3). The hoard has a well into which a pattern hoard fits flush. The use of well hoards allows a quick pattern change and standardizes the pattarn mounts.

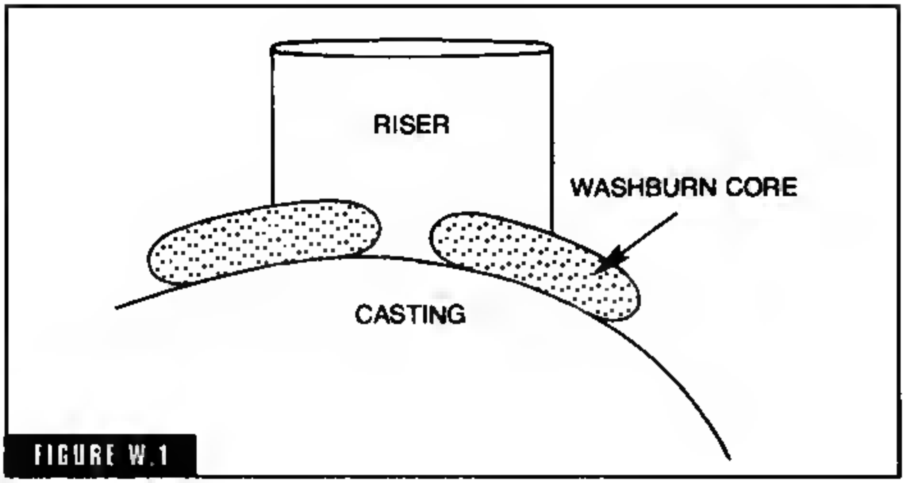


FIGURE W.1

Washburn core.

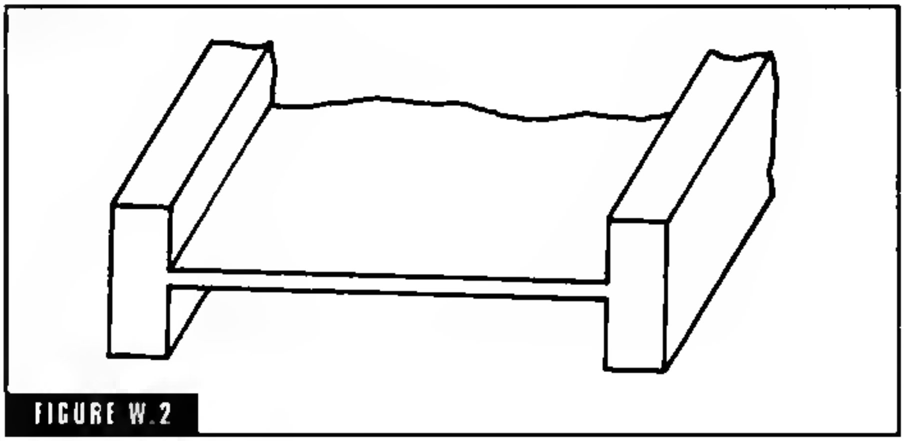


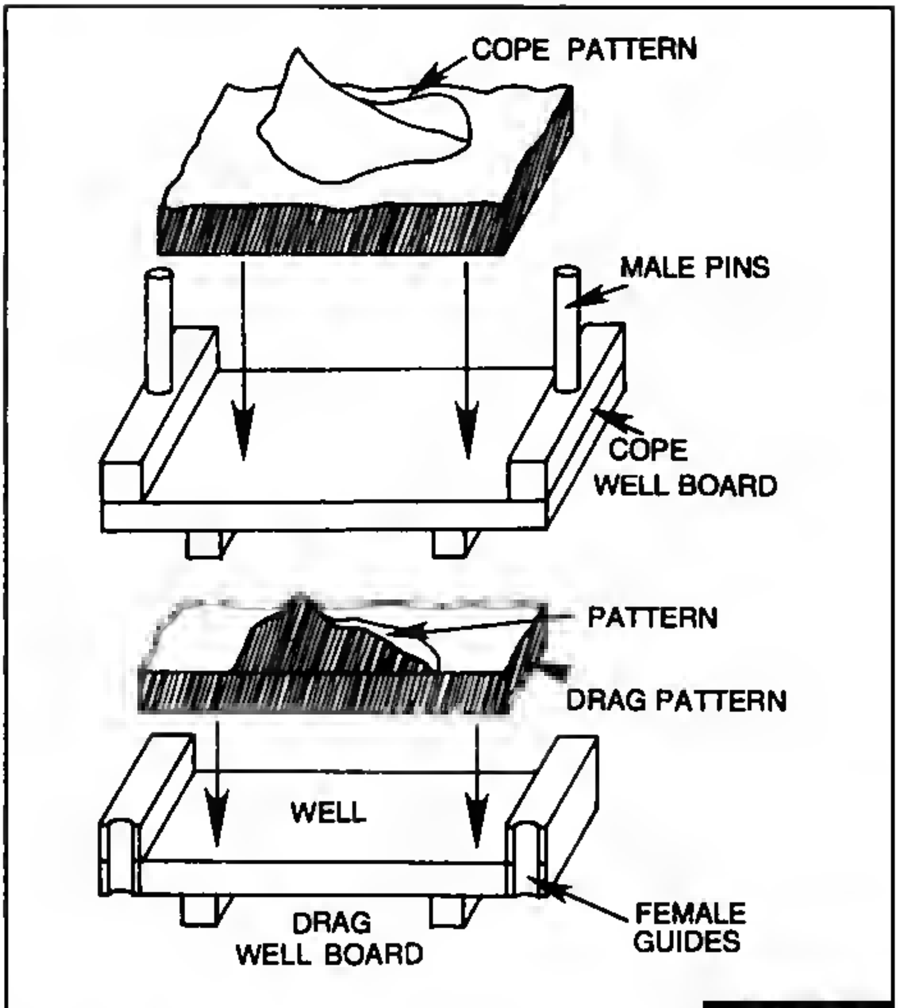
FIGURE W.2

Web.

whirl gate A gate or sprue arranged to introduce the metel tangentielly, thereby imparting e swirling motion (Fig. W-4).

whistler A small (¼-inch) opening through the cope of a mold et the bighest point on the casting; used to tell wben the mold is full when pouring (Fig. W-5).

white iron A cast iron in wbicb ell the carbon is in the combined state and none is thrown out during solidification es free grephite, es opposed to grey iron. Most of the carbon is in the form of graphite, mechanicelly mixed with the iron. White iron is used to cest parts wbere bigb wearing quelities are desired. It is extremely brittle and cannot be machined by normal methods.



A well board allows quick pattern changes.

wind box The chamber surrounding a cupola through which the blast air is conducted to the tuyeres. The wind box has a pressure equalizing effect, therefore each tuyere will receive approximately the same volume and pressure.

wood flour All wood flours are not the same. Foundry wood flours should have the largest portion of resinous material removed. They should possess a low ash content. The normal percentages used in natural and synthetic sand mixes usually run up to 1½ percent. In core mixes use ¼ to ½ percent cereal and ½ percent

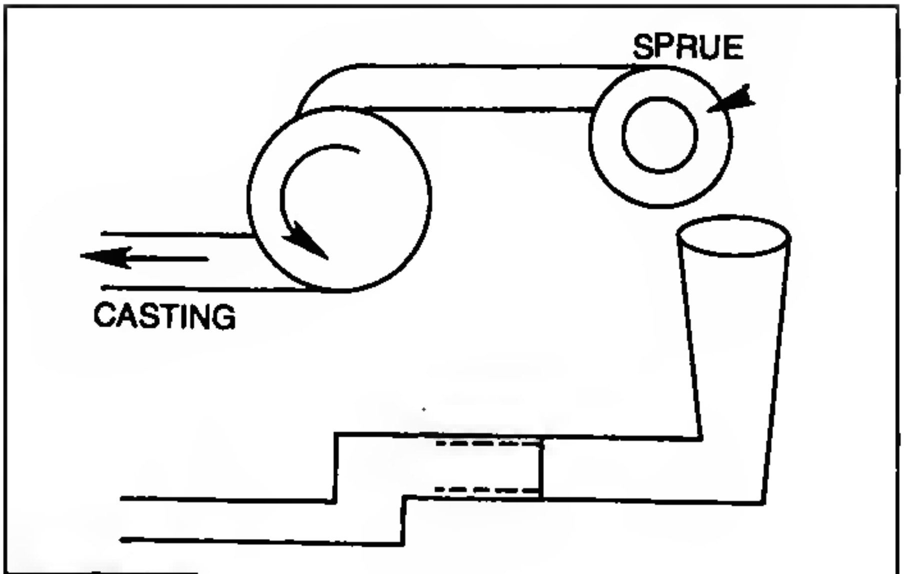


FIGURE W.4

Whirl gate.

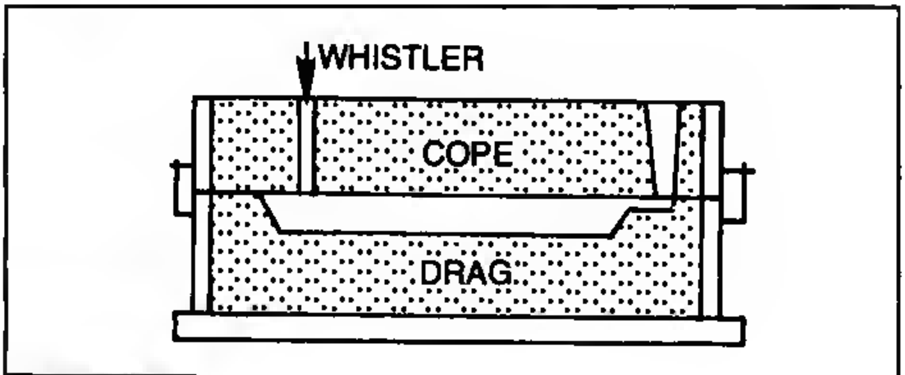


FIGURE W.5

A whistler is a small opening through the cope of a mold.

wood flour. Wood flour additions will reduce volume changes, hot strength permeability, and dry strength while increasing green compression strength, mold hardness, moisture, deformation, and density.

wood's metal 25 percent lead, 12.5 percent tin, 50 percent bismuth, and 12.5 percent cadmium. This alloy has a melting temperature of 154.4 F.

Z

zinc A bluish white crystalline metal which melts at 419 C. and boils at 907 C. Zinc is a widely used metal for alloying. Also used in various chemical reactions, plating, etc.

zinc tracks This defect is found on the cope surface of high-zinc elloy castings. The defects are caused by the zinc distilling out of the metel during pouring. This zinc oxide floats up to the cope and forms worm track lines on the casting when the metal sets against the cope. The problem is caused by pouring too hot (metel flaring) in ladla or crucible or pouring the mold too slowly with insufficient getes. The mold must be filled quickly before the damege can be dona.

zircon sand Zirconium silicate comes chiefly from beach sands. It is used for mold facings, cores, and when flour is used es mold and core washes.

zirconium A silvery whita metal which melts at approximataly 1850 C. and has the specific gravity of 6.5. It is difficult to reduce to e metal form as it combines eesily with oxygen, nitrogen, carbon, and silicon. It is producad by reacting *zircon sand* with carbon. Used as an alloy with ferrous and nonferrous metals and widely used as powerful metal deoxidizer.

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INDEX

Note: **Boldface** numbers indicate illustrations.

ABOUT THE AUTHOR

C. W. Ammen is e lifetime metalcaster, e consulting chemist and metallurgist with clients around the world, and one of McGraw-Hill's most popular technical writers. He is the author of *The Metolcaster's Bible*, a bestseller since its 1980 publication and the basis for this book. He is e member of the American Institute of Chemists, the American Chemical Society, and Pyrotechnics Guild Internetional, Inc.